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WASTEWATER MANAGEMENT STUDY FOR THE CLEVELAND - AKRON METROPOLI--ETC(U)
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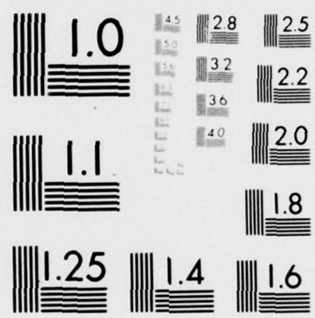

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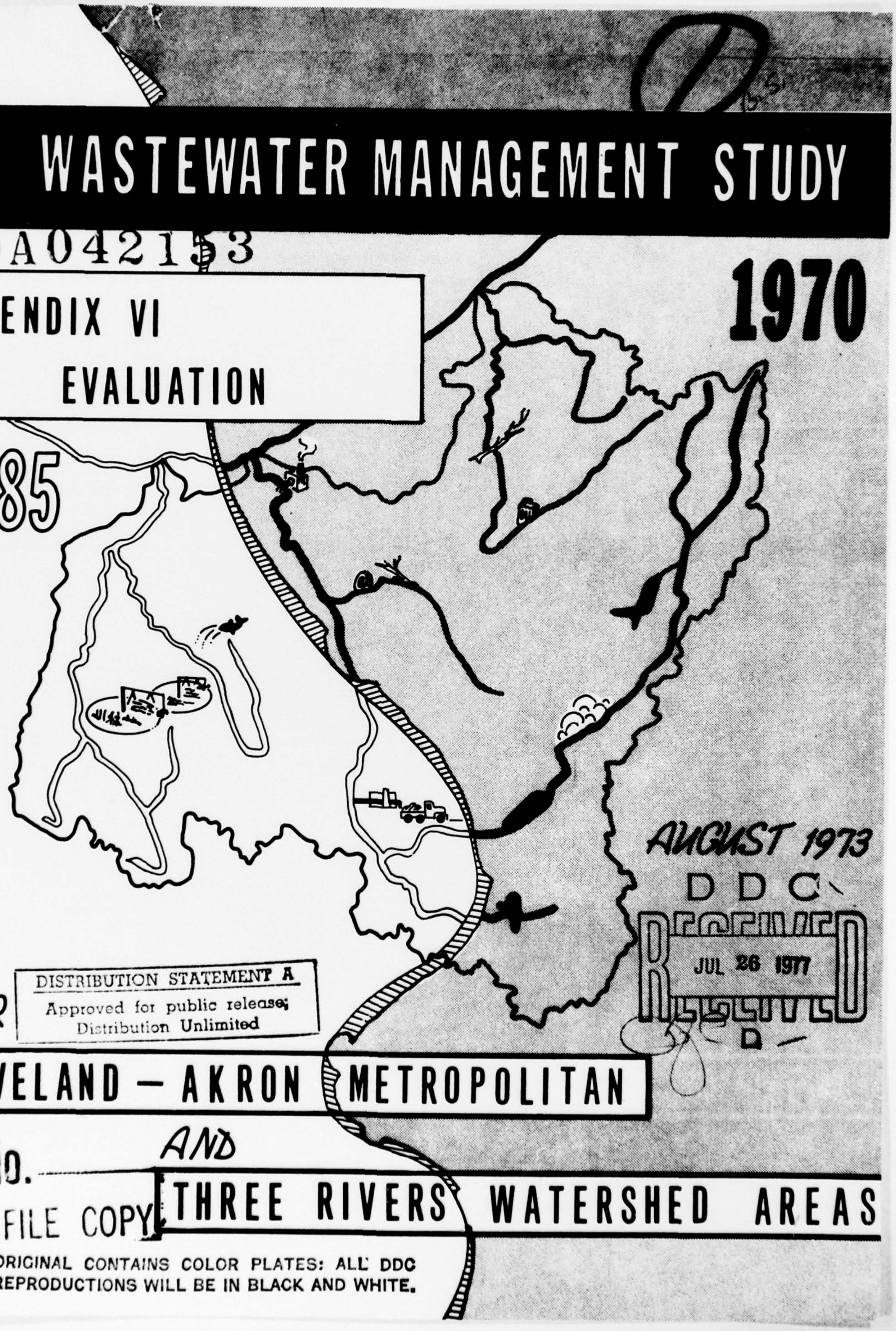
APPENDIX VI
EVALUATION



AUGUST 1973

FOR

CLEVELAND – AKRON METROPOLITAN
AND
THREE RIVERS WATERSHED AREAS

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APPENDIX VI

EVALUATION

OF

6 WASTEWATER MANAGEMENT Study ~~ALTERNATIVES~~ FOR THE
CLEVELAND-AKRON METROPOLITAN AND
THREE RIVERS WATERSHED AREAS.
Appendix VI. Evaluation,

10 James W. Cowden

Prepared by

3 Center for Urban Regionalism
Kent State University
Kent, Ohio
U.S.A.

Under

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Report compiled and edited by

James W. Cowden, M.P.A.
Project Manager

Evaluation conducted by

Center for Urban Regionalism
Kent State University
Kent, Ohio
U.S.A.

Evaluation Team:

James G. Coke, Ph.D., Political Science
G. Dennis Cooke, Ph.D., Ecology
James W. Cowden, M.P.A., Public Administration
John J. Gargan, Ph.D., Political Science
Murray McComas, Ph.D., Geology
John Olive, Ph.D., Ecology
Richard Raymond, Ph.D., Economics
Nancy Schmitz, M.A., Sociology
Eugene P. Wenninger, Ph.D., Sociology;
Director, Center for Urban Regionalism

Consultants:

Thomas Lough, Ph.D., Sociology
Vijay K. Mathur, Ph.D., Economics
Harold Mayer, Ph.D., Geography
Richard McMillin, B.S.C.E., Planning Engineer
James A. Rinier, Ph.D., Geography

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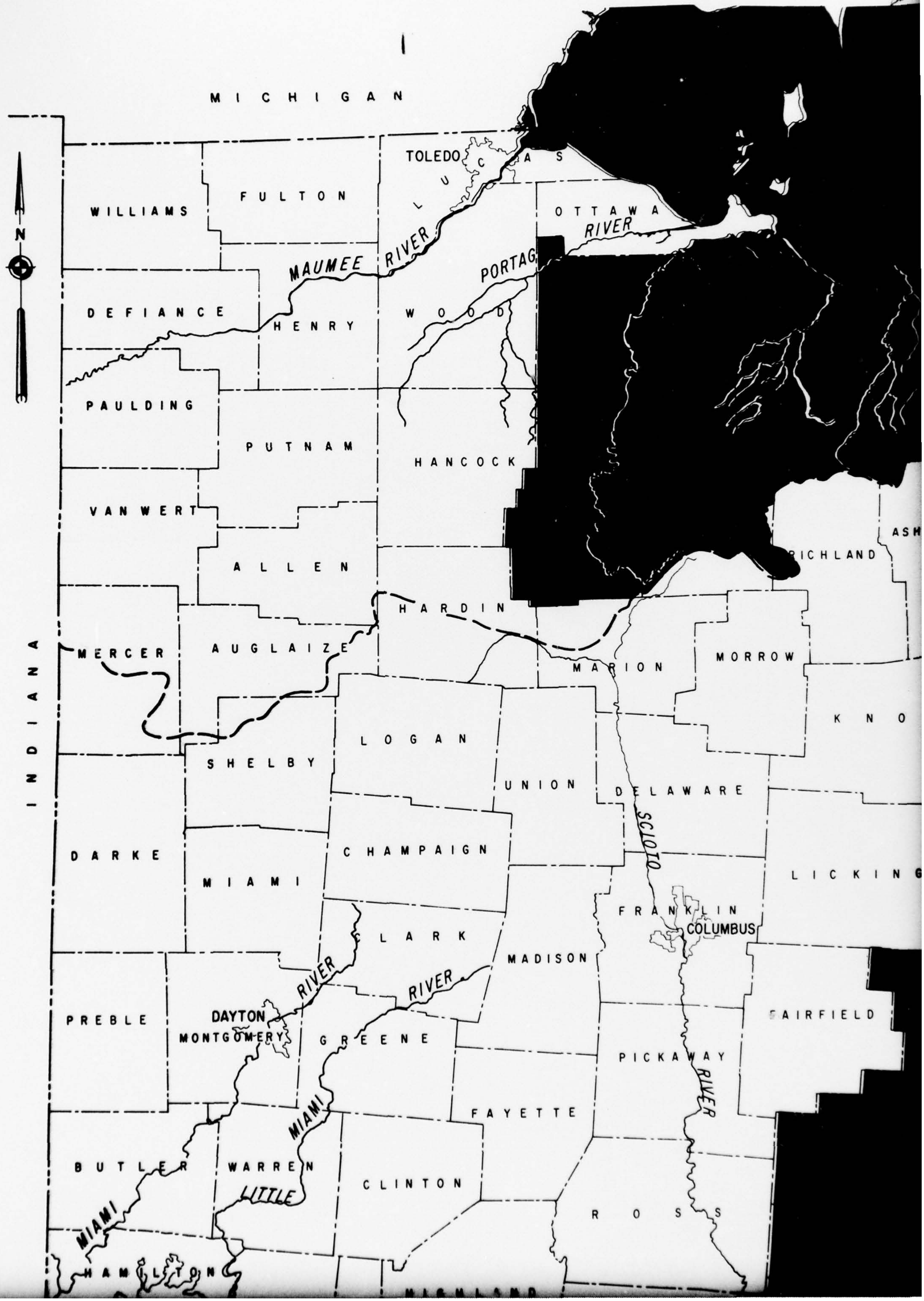
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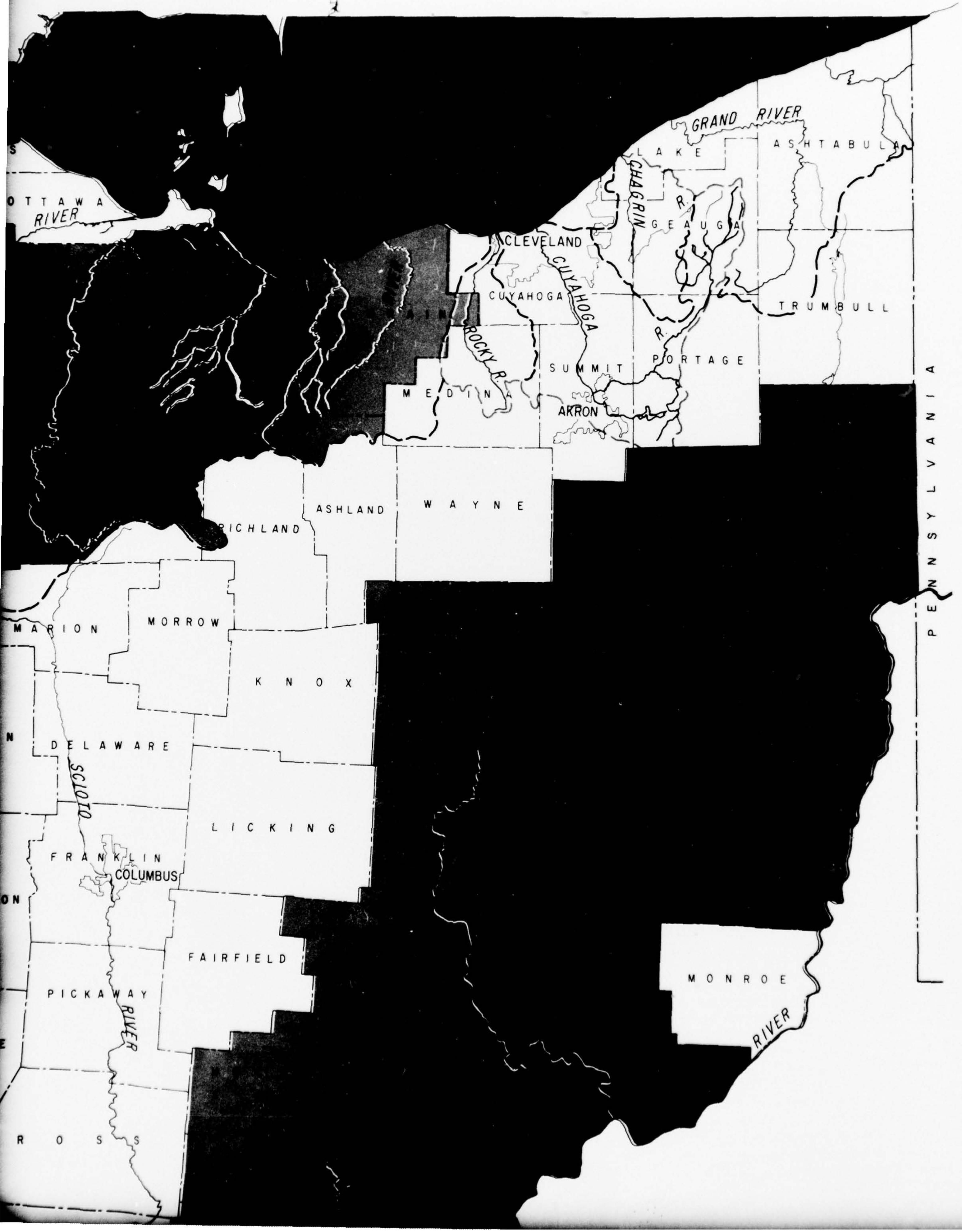
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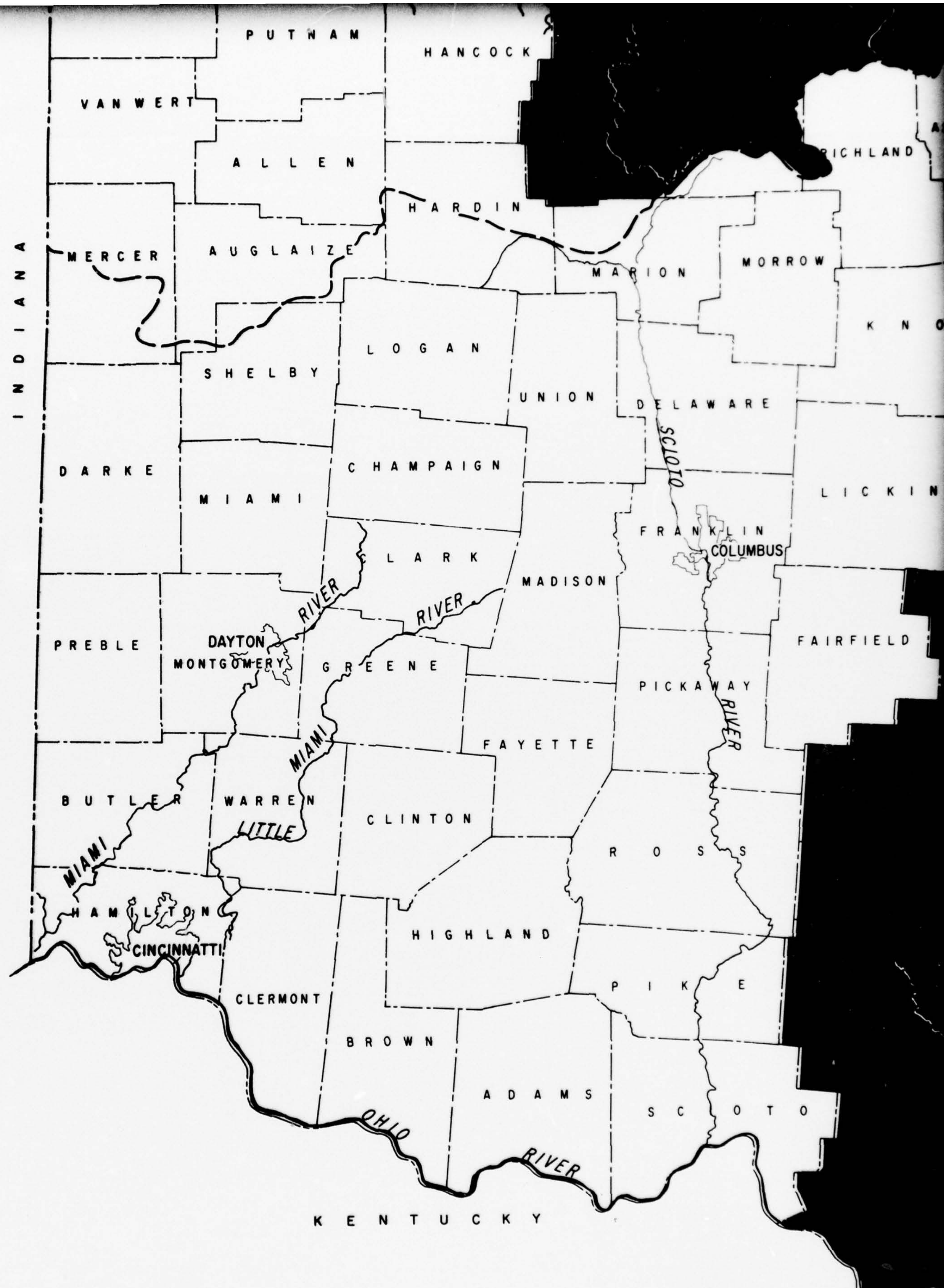
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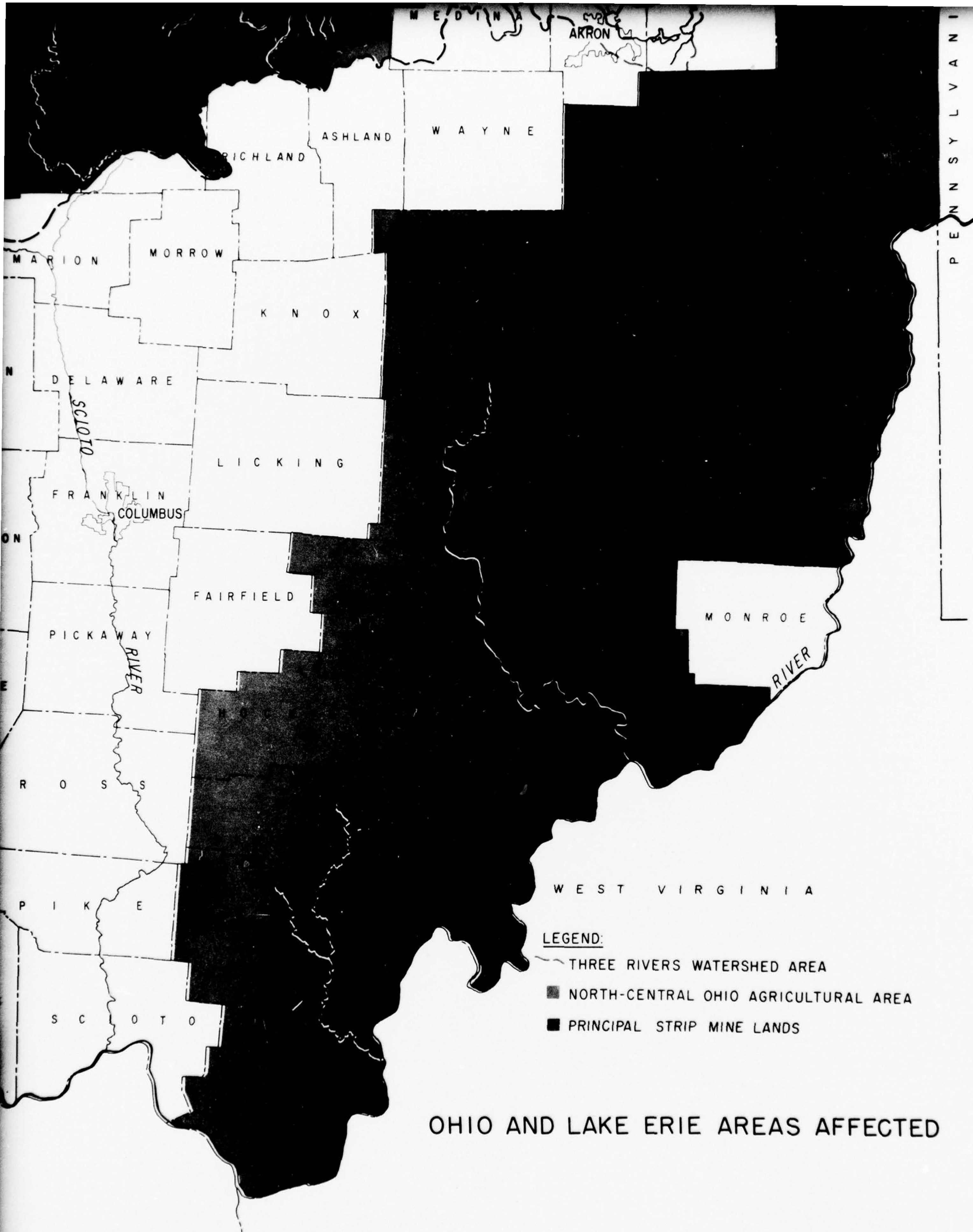

OHIO AND LAKE ERIE AREAS AFFECTED

I. PURPOSE AND OBJECTIVES OF THE EVALUATION

In this Appendix the wastewater management alternatives developed for the Cleveland-Akron Metropolitan area are assessed for environmental impact. The process included (1) the establishment of parameters and descriptions of current baseline conditions within the region for five categories: ecology, esthetics, public health, social well-being, and economics; (2) assessment of impacts of each of twelve alternative wastewater management systems, including the recommendation of corrective actions to be considered by the design team; and (3) the assessment of impacts of each of three representative systems, selected from the set of twelve systems on grounds of environmental suitability and relationship to the national objectives of national and regional economic development, social well-being, and environmental quality.

The objectives of impact assessment are to identify or define: (1) general overall impact of each alternative plan, (2) range of impact within each alternative plan, (3) significant differences in impact among alternatives, (4) significant problems associated with each alternative, (5) knowledge constraints, and (6) need for initiation of more detailed study and/or long term research. The complexity of the problem plus uncertainties in the soundness of the two major wastewater technologies considered (water disposal based upon biological and/or physical-chemical processes and land disposal based upon conventional treatment to secondary levels plus use of "living-land filters" to accomplish tertiary level treatment) forced this evaluation team to concentrate more on the

last three objectives than the first three. What promised to be, at the beginning of the study, a cut-and-dried research project on impact assessment turned into an extensive discussion as a continuous stream of questions were necessarily raised and in most cases only partial answers found.

In some respects this survey scope study does not go much beyond the earlier feasibility study. This is because the knowledge constraints, the significant problems associated with the three major treatment technologies investigated, and the needs uncovered for more detailed study of so many aspects of large scale wastewater treatment forced us to continually examine the underlying assumptions of the technologies under consideration and limited our ability to conduct the more detailed impact assessment which confidence in technology permits. In addition, the fit was poor between resources, manpower, and time available for the impact evaluation and the magnitude and scope of the project.

The November guidelines supplied by OCE with the emphasis upon quantification of impact proved to be too idealistic for our purposes. We discovered quite early in the evaluation process that premature quantification in an area of technology assessment so fraught with implications for public welfare as this one would be very harmful. Rather than developing sets of numbers giving the appearance of precision and measurement but in reality masking numerous subjective judgments, we preferred to bring the judgments to be made to the surface where possible and to provide decision makers with the rationales as to why judgments must be made.

Our task as defined by the Buffalo District was to act as the "conscience" of the project. This forced us to raise questions and to investigate areas which might not come under a more usual, narrow definition of impact assessment.

A. Purpose of Evaluation

In the long history of public works in America, there are, unfortunately, more than a few examples of projects undertaken for the best of motives, directed toward a useful objective, that have turned into environmental nightmares due to the accrual of unplanned and unforeseen effects. The development of water resources has not been exempt from the Jekyll-Hyde syndrome.

The wastewater management program, developing concurrently with the burgeoning national concern for the environment has several excellent objectives and motives which, in the Three Rivers Basin apply to one of the nation's most polluted rivers--the Cuyahoga--and a highly polluted Lake Erie. Yet the sheer urgency of doing something about these conditions makes it more necessary to assure--since it is ecologically impossible to do just <u>one</u> thing--that the multiple attendant effects of wastewater management are positive, or at most, a lesser evil.

In general terms, the purpose of evaluation is to discover, in advance of final plans or construction, any potential for ecological mischief or disaster, any technical flaw or inadequacy, and any opportunity for protection or enhancement of the larger environment. Identification would be followed by investigation and by iterative consultation with the planners, to achieve modification or refinement of plans toward greater harmony and

efficiency. Evaluation, in conjunction with plan formulation, should provide the real test for project validity.

The objectives of wastewater management planning within the Three Rivers Basin are many, ranging from broad general goals to more specific technical objectives. One purpose of evaluation of plans is to determine whether, and to what extent, those goals and objectives have been met. The State of Ohio and the region generally are concerned with the development of water for recreation, domestic, industrial, and agricultural uses. For the basin, this would translate into protection of the public water supply and the restoration of stream and lake quality for fishing, water contact sports, and esthetic appreciation. Planning objectives must, of necessity, be more specific. The primary directive is to prevent continued degradation of the water resources of the basin; this to be accomplished by the limitation of pollutants in effluents from whatever source, to be attained by degrees, in a time phasing established by the Federal Water Pollution Control Act of 1972. The second technical requirement is to maximize the reuse potential of all products resulting from wastewater treatment, including the renovated wastewater.

Even broader objectives are promulgated by the Water Resources Council, objectives which must be considered in any water resource development seeking federal funds. These considerations are the contributions to national economic development, environmental quality, social well-being, and regional development.

While these multiple objectives are not necessarily incompatible, it is inconceivable that all can be achieved equally or to the same degree in any single plan for wastewater management. Multiple alternatives must be developed, incorporating different technical components and systems, or combinations of these systems. To provide the necessary information for the selection among those alternatives, of one or several plans most compatible with the objectives and least afflicted with secondary effects or long-range intractability, is also a major purpose of evaluation. The search for this alternate preference essentially involves a number of subsidiary purposes in evaluation which are here enumerated.

1. To define the current conditions of the Three Rivers Basin area as a prelude to identification of change in the ecology, the state of public health, the economy, the social and institutional pattern, and the availability of esthetic amenities.
2. To assess the alternate designs for reliability, for relationship to environmental health, and for ability to achieve goals under an expanded scale of operation, regional scope, stricter and more inclusive standards, and increasing complexity of input; to search for secondary, delayed, and cumulative effects of process components.
3. To anticipate the effect of development on the functioning ecosystem and the resource base, estimating the probability and degree of risk, and the secondary and long range biological effects, with a view to the protection and restoration

of the environment as opposed to narrower, regional concerns and the imposition of new burdens.

4. To preserve an orientation toward the future by due regard for long term maintenance and enhancement of the environment as opposed to short term local usage, by discovery and elucidation of irreversible ecological effects, by reviewing the lift cycle effect of proposed construction, by consideration of the alternate effect on resources and energy, relating expected demand to resource capabilities, and by concern for the increasing value of scarce natural environments.
5. To provide, during the planning process, information to the planner to enable the refinement of structural or nonstructural components; by identifying change and its relationship to specific system components, by interpreting impacts relative to objectives, by weighing one impact against another, and finally, by suggesting revisions to reduce disfunctions and enhance harmony with the social and physical environment.
6. To suggest the existence of alternate possibilities of achieving objectives, to consider nonstructural methods, nondevelopment options, and the preservation of flexibility for the future.
7. To identify areas where the data base is inadequate, where research is needed, where the environmental effect of a particular action is unknown, and where there is a need for expanded and continuous monitoring and evaluation of change.
8. To review and assess the long range implications for wastewater management of demographic changes, future resource demands and supplies, and the underlying trend in technology and patterns of social behavior that influence these factors.

9. To explore, by economic analysis, the resource allocation consequences of investment or expenditure decisions, to assess the institutional realism and political feasibility of the several alternates, and to relate to the public anxiety over the deterioration of the environment.

10. To provide the decision-makers with an array of impacts, organized by alternatives, assessed for significance, supported by data, showing how each affects human values and goals through changes in resources and environment, to enable the comparison and selection among alternatives based on the relative desirability of the several systems.

B. Description of Report

This report is broken into two major components, the report on the evaluation process and results, and a series of ten background papers developed on various aspects of wastewater management technology. The report on the methodology process includes a statement of methodology, sections on parameter development, regional planning objectives and regional characteristics, and evaluation and comparison of land based and water based advanced wastewater treatment technology. The meat of the evaluation report is contained in sections VII, VIII, and IX: the evaluation of the twelve alternative regional systems developed, the evaluation of the four phased and costed systems, and the conclusions and recommendations. The attachements include regional characteristics for areas not originally included in the scope of the study, analysis of wastewater projections for the target area,

several papers on fiscal and economic aspects of a regional wastewater project (including distributive equity), some brief comments on political acceptance of innovation in this area, and a short paper on the technological problems associated with aerated lagoons.

The purposes stated in this section were recognized as ideals to be approached as closely as possible. The extent to which the evaluation did this is indicated in the methodology and subsequent analysis sections.

II. METHODOLOGY

A. INTRODUCTION

The planning and evaluation of wastewater management systems for the Three Rivers Basin takes place in the midst of change. The one certainty that may be stated about the years between now and 2020 is that they will be marked by rapid and dynamic change. The rate of change, as well as change itself, must be one of the major influences on planning.

The future will inevitably consist of systems of increasing complexity, physical, social and economic. The combination of population growth and urban growth have mutliplied the complexity of the system in which the nation exercises its choices. To an ever increasing extent, action on one of a series of highly interrelated subsystems will reflect on others. Wastewater, as an aspect of water resources, represents one of these subsystems. The complexity of physical and environmental systems is mirrored in a complexity of social relationships, of individuals to others, to the environment, and to governmental and decision making processes.

Yet the complexities have been approached with a series of inadequacies. A recent study on metropolitan water management[1] cited the fragmented structure of metropolitan water resource institutional arrangements, the limited outlook and parochial orientation of metropolitan professional personnel, and the inadequacies of both data and analytical structure which hindered technically adequate planning and restricted the breadth of vision to geographically and functionally

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[1] Urban Systems Research and Engineering, Inc., Metropolitan Water Management--Case Studies and National Policy Implication. June, 1971.

narrow viewpoints. The situation represents a pervasive source of inefficiency in the planning and decision making process. In particular, the existing forecast methodologies have been characterized as primitive and unsuccessful. Forecasts must be seen as a tool of systems analytical planning, with supply, demand and other elements of the system dependent in considerable measure on variables within control of the policy makers.

In a discussion of OCE guidance, INTASA Interim Memorandum III, indicated that the relationships between water quality and the extensive list of potential impacts suggested by OCE, were not obvious. "They are complex, interdependent, indirect--they involve various disciplines. Many of them are uncertain, partly unknown or ill defined." The memorandum goes on to suggest that there is a danger for the evaluators in the assessment of certain secondary impacts, characterized as "active" and requiring an outside agent to actualize it. The evaluation of such impacts is said to be dependent upon probability and it is suggested that the proper course of action is for the evaluators to take part in the planning process to help generate the full range of benefits of the project. The discussion did not include the potential for negative impacts caused by outside agents or for opportunities foregone which should be part of an adequate evaluation. Elsewhere in this report we have discussed the necessity of considering water resources planning within the context of government response to the solution of the whole range of social, economic and environmental problems. Nevertheless, the opportunity afforded the evaluators to participate in an iterative process with the engineering contractors and plan formulators was recognition of the in-

separability of planning and evaluation. The task of the evaluation group included information gathering, analysis, the display of information and consequences of action, and the recommendation of courses of action for the decision maker. In accordance with OCE guidance the research, the information display, and the analysis has gone beyond the functional planning of wastewater management to sectorial water resources and multi-sectorial considerations.

B. GENERAL PROCESS OF EVALUATION

The evaluation group became impressed, early in the process, with the complexity involved in water resource planning. First, water is seemingly related to almost every aspect of organized human activity. There are interconnections among water resources, social life, and economic activity. It is almost impossible to distinguish a sphere of "water related activity" from the rest of life. Similar constraints apply to planning and institutional relationships.

Second, the complexity of water activities is usually coordinated through a complex policy process, involving multi-stage increments, built upon past policy and experience, revised on the basis of accumulated information, until new policies are developed. It involves initially, the recognition of a problem and a set of value systems from the very beginning. The development of sufficiently inclusive policy alternatives in response to the recognition of a problem has been traditionally inadequate.

A third area of complexity in the management of water resources is in the optional mechanisms for coordination. We have not assumed

that the only options are those of centralization and decentralization. It is possible to coordinate functional relationships in various ways--physically, in terms of plant regionalization, and administratively, by a variety of bureaucratic integrations.

The complicated system of water relationships (which includes the environmental complex), policy processes and possible coordinating techniques requires evaluation from a complex perspective. Past analysis has assumed that public decision makers have a well-developed "preference function" about alternative outcomes. Yet this is seldom the case. Choices and preferences are generally developed in relation to the relevant options presented. Complex questions are often decided by an intuitive process based upon past experience. Preferences may depend on how a system has operated in the past; a potential output may have a low demand because of lack of experience

Another extremely difficult evaluative problem has to do with the interest of future citizens. Some water related resources are irreplaceable. What is the value or cost of eliminating certain natural resource options forever and what responsibility does government have to preserve these options for unborn citizens? Should we maximize the welfare of this generation at the cost of posterity?

Whether philosophical or practical, there is no question but that the concern for the future formed a backdrop for the evaluation.

In recognition of the necessity of pursuing the evaluation from a complex perspective, an evaluation group was assembled from the faculty and staff of the Center for Urban Regionalism, Kent State University, the University of Akron and Cleveland State University. The group represented expertise in a wide variety of disciplines

including bacteriology, biology, ecology, economics, geography, geology, limnology, political science, sanitary engineering, sociology and soil sciences.

The purpose of the evaluation as indicated in the previous section gradually developed into a detailed array during the course of the evaluation research. Initially, the function of the evaluation group was designated as four areas:

(1) To develop a set of parameters, or elements of potential changes in five areas: economic, social, ecological, public health and esthetic--to be used in the assessment of alternative wastewater management systems.

(2) To describe the current baseline conditions within the study area, aligned by parameter groupings.

(3) To assess the beneficial and adverse effects of each alternative wastewater management system, suggesting modification for adverse impacts, and

(4) To assess the impacts of the alternative systems in relation to their contributions to national objectives of national economic development, environmental quality, social well being and regional development.

The evaluation group had the advantage of extensive guidance from the Corps of Engineers and the reports of the original five feasibility studies of wastewater management. As the initial effort in a reiterative study, they were valuable in indicating appropriate directions of concern. A decision was made, based on the background material, to investigate the entire range of impacts that would result from improved water quality and from the conceptual and

policy changes and the physical structures required. The decision was based on the concept that any lesser approach would result in prejudgment of impact potential.

Our initial parameter listings were constructed through individual research and group review of known system elements, and elaboration of secondary impacts on the larger environment resultant from those impacts. These parameters are presented in subsequent pages. While many of these parameters have currently been downgraded or identified as insignificant by further study, the listings will identify the area of inquiry and hopefully reduce questions as to why a particular item was not evaluated.

As the program developed, and as planning elements and alternatives were submitted, the research expanded into areas such as aerated lagoons, the resource requirements of the several systems, and other questions directed at the underlying technology.

While this outline of methodology indicates some compartmentalization, the various elements of research and assessment were carried on concurrently, as plans were submitted for evaluation. Baseline data on the socio-economic and environmental conditions of the study area was being accumulated while parameters were still under development. Regional objectives were acquired in the same way. In the subsequent sections on Regional Objectives and Regional Characteristics, the various deficiencies in this type of regional information were identified with indications of the constraints to planning and evaluation. Adequate and reliable physical, socio-economic, environmental and ecological data are essential to the process. While we were able to obtain accurate demographic and economic data, there are deficiencies in several categories of environ-

mental data due to the lack of measurement in the basin. There is also a significant lack of information on life styles, social preferences and human behavior generally, especially with regard to forecasting the future.

It has been said that goal setting and goal achievement is what planning is all about. The search for objectives was conducted among all the public and semi-public planning agencies and some private, with the eventual conclusion that there is a deficiency in clearly defined goals and objectives for the region, and perhaps more serious, an inadequacy of procedures for establishing them. The establishment of goals has been limited by the specific interest of the individual agency, and even the sum of the subgoals will not equal an optimized whole.

Corps guidance identified impact assessment and the measurement of effects as separate aspects of methodology. Impact assessment is described as the identification of the achievement of the program technical goals in relation to the alternative plan impacts on the ecological, social and other aspects of the region. In practice it has involved an analysis of inputs, processes, plants, and outputs.

The second area is the measurement of effects which involves the identification of the beneficial and detrimental contributions of alternate systems. Both identification and measurement have been essentially a continuing process in the evaluation. Each evaluator in the group independently assessed the elements of each alternative with particular concentration in his own specialty. There were continuing interchanges of ideas through regular meetings, which established both antagonistic and supportive elements. The elements

were displayed in a way to allow future trade-offs without submerging any aspect of professional judgment.

In addition to regular meetings among the evaluating disciplines, occasional opportunity was afforded to maintain an iterative exchange with the engineering contractors, to exchange ideas and to clarify impressions of the various alternatives. Fairly early in this overall process of exchange, the evaluation group was able to identify similarities and differences among the alternates or system components, and thereafter our general evaluation was developed by component.

The development of a component evaluation was also a part of the process whereby the parameters were reduced to those of greater significance. The major elements or components included Sources, Collection, Treatment, Residuals, and Disposal. Each major component was divided into subcomponents, each with its capacity to induce change.

The <u>sources</u> of waste included industrial and domestic sources, urban and non-urban runoff, cooling water, and general aspects common to all classes of sources. The particular significance of the inclusion of this category is the opportunity to consider means other than treatment for the reduction and control of wastes. Under <u>collection</u>, we are referring to the collection system itself, the requirement for major interceptors, the interconnection of present sewer plants where regionalization is indicated, the establishment of stormwater collection basins and other changes, both structural and non-structural for waste control.

Under <u>treatment</u>, the subcategories of industrial/domestic land treatment, advanced waste treatment discharging to water, stormwater

treatment and cooling water control are indicated, with the changes imposed by each and the impact area among the five categories listed. Among the major considerations imposed is a change in the current philosophy of waste treatment.

The final two categories include residuals and disposal, with residuals including effluents, the various types of sludges and the gaseous residuals from the several types of plans. Under disposal, consideration was given to the potential for transfer or recycling of the residuals, with consideration of incineration, land application, strip mine use, the disposition of treated agricultural crops and consideration of "ultimate" disposal.

The practice of disaggregating treatment systems into components and subcomponents enabled a simplification of a complex process for easier analysis by disciplines not normally involved with sanitary engineering. It expanded the area of environmental interest to all members of the group and reduced the complexity of plan evaluation. At the same time, individual components and subsystems could be readily aggregated into an alternate system analysis.

As a procedural matter, the parameters used to measure impacts are listed in the succeeding pages of this section. The question of the units used in measurement of impacts deserves a more comprehensive answer. There are certain units which are obvious and meaningful and these have been used where they exist. Such things as energy and chemicals required, the tons of sludge produced or burned, the acres used by each plan and the families displaced, the recreation days made available, have been displayed in the evaluation where warranted. Where quantification is not obvious it has been used sparingly with recognition of its subjective nature.

The evaluation group has reviewed a number of suggested matrix systems that are dependent upon quantification of a range of impacts. It has thus far rejected these as an attempt to structure the unstructurable. While any evaluation involves value judgments, the attempt to quantify impacts and to produce some kind of a composite impact table to score the various systems, is to throw more impediments in the way of decision making. At this time, there does not appear to be any common unit allowing us to quantify the amount of secondary environmental pollution to the point of arriving at an overall impact. A safeguard is needed against false precision and the non-quantifiable should be left in plain textual terms in which form it must ultimately be assessed by decision makers.

The question of how the beneficial or detrimental character of impacts be determined is simplified in considerable degree by the assessment of sub-components which have a less complex impact. Essentially the determination was made based on the actual or potential damage or benefit to people or the environment. In many respects, the characterization of a plus-minus value would be obvious from the nature of the parameter.

Another point is the method of establishing the relative significance of the different impacts and here there are a variety of indices. Obviously the magnitude of impact is significant, based on miles of stream, acres of forest, or numbers of people protected. Such questions of whether an impact is long-term or short-term, or a temporary change versus an irreversible effect are significant. The assessment of whether a pollution abatement technology reduces overall pollution or merely accomplishes a transfer would establish significance.

In the course of the investigation, matters of significant concern to the evaluation group or the individual discipline were developed into specific papers which were incorporated into specific areas of this report. The content will, in each case, indicate its relationship to the overall evaluation. In general, such separate papers dealt with systems or subsystems. In a real sense, the overall evaluation process has permitted the retention of a total system approach and reflected rather than submerged the individual disciplinary inputs, which then have been displayed in organized fashion. In the evaluation sections, the significant impacts have been aggregated into appropriate groupings for purpose of convenience, but the significant inputs remain.

Finally, our evaluation procedure has essentially been established and completed on the basis that the analyses and judgments of well informed experts are meaningful, reliable and in the aggregate provide a better estimate or evaluation than a quantified score sheet. The validity of the expert judgment is, of course, limited by the quality and adequacy of the information provided to them or developed by them as a basis for their evaluations. In this respect, the research has been as exhaustive and comprehensive as time and resources could provide.

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III. PARAMETER DEVELOPMENT

A. INTRODUCTION

The contract called for the evaluation team to establish parameters for the subsequent impact assessment in five categories of concern: ecology, public health, esthetics, social well-being, and economics. Included under these labels were also parameters on more general environmental concerns, recreation, and institutional-political factors.

The following parameters were developed by relating known technology in wastewater treatment to existing conditions in the river basin area, or alternatively to factors which remained unknown until design completion, such as cost factors. A number of apparent instances of overlapping have been included in the parameter listings, such as recreational concerns. Such redundancy was occasioned by varying perspectives of a critical factor and in some instances, by a concern for emphasis. We developed groupings of parameters or characteristics which are capable of change and which may be more or less significantly impacted by the planning and implementation of particular wastewater treatment systems. The parameters were circulated to the technical contractors, although not as early as desired, as part of the iterative process between evaluation and design.

During the development of parameters we uncovered general considerations that have influence on plan analysis and public and official review. In particular the following questions become significant:

Scope

Will the plan be truly regional and inclusive in scope; will it consider all types of waste, including non-point sources; does it embody a concept of total water management; does it consider complete systems?

Political Feasibility

Will the treatment system exhibit a sense of institutional realism; can it be made both palatable and essential to politician and public?

Future Orientation

Will the plan be sufficiently flexible to comprehend future changes in population, land use, technology and standards other than those projected; will the quantity of water use and wastewater be viewed as fixed or as a variable subject to economic and political constraints; will there be due regard for long-term maintenance and enhancement of the environment as opposed to short-term local uses; will there be any irreversible ecological alterations involved?

Significance

Is something obvious going to happen as a result of the plan; will recognizable and useful improvement take place in the quality of Lake Erie water and the several streams and rivers?

Recycling

Is there enough water to waste; can we substitute a water recycling concept, a continuing use of resources, for a disposal orientation; does the plan account for the return of all elements to the ecosystem or are we engaged in the development of end products for "ultimate disposal"?

Various constraints affected our development of parameters and our later applications of them. For one thing, there is no unambiguous social welfare function that can yield clear and ordinal rankings. We are dealing with sets of contingencies in a systemic framework, each with interdependencies that makes ranking by significance inadvisable if not actually misleading. The question of significance and impact is as much a function of the specific plan proposed as it is of any integral value.

Another constraint existed in the stage of regional development of the target area. Regional policy mechanisms are relatively immature. Approaches to regional cooperation have been consistently marked by antagonistic local interests. Coupled with this is the lack of comprehensive, current data banks in any readily available form. There is consequently a lack of regional awareness and gaps in planning not usual in many other major metropolitan areas.

The parameters are presented as developed by the team members assigned to each category. Time constraints prohibited putting the categories into a uniform format.

B. ECOLOGICAL PARAMETERS

1. Introduction

An assessment of ecological impacts of wastewater alternatives for the Three Rivers Watershed should be based on structural and functional characteristics of mature, stable, and healthy ecosystems. The ecosystem is the basic functional unit in ecology. The term ecosystem was first proposed by the British ecologist A. G. Tansley in 1935. It is a theoretical concept that enables ecologists to study in a systematic manner complex interactions between living organisms and the physical environment.

Plants and animals and their nonliving surroundings are interrelated in the ecosystem to such an extent that the entire unit functions as a whole--a kind of super-organism. The flow of energy between the living and nonliving components leads to clearly defined food chains, biotic diversity, and a regulated exchange of material between the living and nonliving parts.

2. Ecosystem Description

For analytical purposes, the ecosystem can be subdivided into structural components and functional processes. The following structural components may be recognized: (1) inorganic substances (C, N, CO_2, H_2O, etc.) involved in nutrient cycles; (2) organic compounds (proteins, carbohydrates, lipids, humic substances etc.); (3) climate regime; (4) producers--mostly green plants which are able to manufacture high energy food materials from simple inorganic compounds; (5) consumers, mostly animals which ingest other organisms to particulate organic matter; (6) saprotrophic organisms, mostly bacteria and fungi, which digest complex compounds of dead organisms, absorb some of the decomposition products, and release inorganic nutrients and organic substances that may regulate other biotic components of the ecosystem. Inorganic substances, free organic compounds and the climate regime represent the abiotic components, and the producers, consumers, and saptrotophs comprise the biotic and biomass portion of the ecosystem.

From the functional point of view, the ecosystem contains an autotrophic component (autotrohpic = self-nourishing), in which sunlight is used by green plants to synthesize complex organic materials from simple inorganic substances, and a heterotrophic

component (heterotrophic = other-nourishing), in which the complex organic materials are rearranged or decomposed into simple substances with the release of stored energy. These major functional divisions may be further analyzed in terms of (1) energy circuits, (2) food chains, (3) diversity patterns in time and space, (4) biogeochemical cycles, (5) development and evolution and (6) control mechanisms.

Ecosystems may range in size from small microecosystems contained in the laboratory to large units comprising an entire watershed. Groups of watersheds or even entire biomes or deciduous forests, grasslands, tundra and deserts, for example, may be regarded as ecosystem units.

3. Ecosystem Evaluation

Over periods of millions of years ecosystems, like living organisms, have evolved into characteristic entities with well-defined biotic and abiotic components. Ecosystems are capable of self-maintenance and self-regulation as are their component populations and organisms. The interaction of material cycles and energy flow generates a self-regulating or homeostatic control that requires no outside regulation. Really good homeostatic control comes only after a long period of evolutionary development. New or immature ecosystems, because of poorly developed control mechanisms, tend to oscillate more violently and are easily disrupted by external disturbances. Mature ecosystems, on the other hand after long periods of evolution have developed homeostatic controls to such an extent that very great external

forces are required to upset their equilibrium.

Unfortunately, man, acting principally as a geological agent, has been able to disrupt the internal, self-regulating control mechanisms of many ecosystems through his careless and unwise use of the system's structural components. When man destroys autotrophic organisms, increases soil erosion, releases toxic substances or introduces organic materials such as domestic sewage at rates that cannot be assimilated, the control mechanisms may falter, resulting in the destruction of the system, or in the creation of an unstable ecosystem that is easily disrupted by factors that normally exert very little effect on the system.

Mature, stable, and healthy ecosystems have a number of attributes or characteristics that can be evaluated to determine the system's state of maturity (Odum, 1969). Indirectly, these attributes reflect the degree of stability or the "health" of the ecosystem.

A list of attributes or parameters that can be used to evaluate ecosystems is shown in Table 1. The parameters are divided for convenience into (1) energetic parameters, (2) structural components, (3) life histories of oganisms present, (4) nutrient cycles, (5) selection pressure, and (6) overall homeostatic conditions. Column 2 gives the typical characteristics expected for each of the parameters in unstable, immature ecosystems such as those disturbed by man. In Column 3, the characteristics of typical mature, healthy, and stable ecosystems are shown.

Methods for evaluating each of these attributes or parameters are well established for some parameters, but poorly defined for

others. The numbers in Column 4 indicate those parameters for which widely accepted methods are available for evaluating the particular parameters. The numbers also indicate a priority list which should be considered in choosing parameters for actual field evaluations of ecosystems. These parameters apply to terrestrial as well as aquatic ecosystems.

Excellent evaluations of most ecosystems can be obtained by using only a few of the parameters listed in Table 1. For example, mature, healthy ecosystems are characterized by certain dominant kinds of plants or animals. These organisms largely control the energy flow and strongly affect the environment of all other species. The presence and relative abundance of the dominant organisms are well known for most ecosystems. For this reason, a relatively simple inventory of the dominant organisms can be used very successfully as an index of the overall condition of an ecosystem.

For convenience in applying ecosystem parameters to the evaluation of ecological impacts of wastewater treatment alternatives, the Three Rivers Watershed may be divided into terrestrial and aquatic ecosystems. Each parameter listed in Table 1 applies to both terrestrial and aquatic systems. Each of these systems include an aerial zone and a soil and sub-surface zone (Table 2). Terrestrial ecosystems may be further divided into mature forest, early successional woodlands, perennial cropland, annual cropland, and urban-industrial areas. Aquatic ecosystems include streams, rivers, natural lakes, peat bogs, water supply and flood control reservoirs, and recreational ponds.

4. Definition of Ecosystem Parameters

a. Community Energetics

Community Energetics refers to the rate of energy flow through the biological components of an ecosystem. The gross production/community respiration (P/R) ratio is probably one of the best functional indexes of the relative maturity and stability of the ecosystem. In young, unstable ecosystems, the rate of total photosynthesis exceeds the rate of community respiration so that the P/R ratio is greater than one. High P/R ratios are maintained by man in annual agricultural crops through cultivation, use of fertilizers and pesticides and by harvesting at times when the yield is optimal.

In stable and mature ecosystems, the P/R ratio approaches one because of the increased rate of community respiration. The energy fixed in organic compounds tends to be balanced by the energy used for maintenance in the mature or climax ecosystem. In the case of organic pollution of water, P/R is initially much less than one, but approaches one as production increases and respiration decreases.

As ecosystems mature, organic matter or biomass (B) accumulates resulting in decreased gross production/biomass (P/B) ratios and increased values for the amount of biomass supported per unit of energy flow (B/E ratio). Net community production (GP-R) thus decreases as ecosystems mature (Odum, 1969).

The transfer of energy from green plants through a series of consumer organisms until all the energy is dissipated as heat is known as a food chain. Food chains are of either the grazing or

the detritus type. Grazing food chains begin with herbivores that feed on the green plants and end with carnivores that feed on the herbivores and other carnivores. Detritus food chains begin with dead organic matter, pass into micro-organisms, then to detritus feeding animals and finally to their predators. Food chains vary considerably from one ecosystem to another. Young, rapidly developing ecosystems usually have short, simple, grazing-type food chains, while the more mature ecosystems have long, complex, interconnected, detritus-type food chains.

As ecosystems mature, an increasing number of mechanisms develop that reduce grazing, such as the accumulation of indigestible cellulose and lignin, feedback control between plants and herbivores, and increasing pressure from predators. These mechanisms enable the ecosystem to exert greater control over the physical environment and mitigate the effect of rapid and severe changes in the physical environment. Thus mature ecosystems maximize for protection while young ecosystems maximize for production.

(1) Indicators of Community Energetics in Aquatic Zones

Energy flow rates can be determined from changes in biomass and from direct measures of metabolic rates. Direct estimates of aquatic energy flow rates have been made in only a few lakes within the Three Rivers Watershed. Energy flow studies have not been conducted in the streams or rivers.

Despite the lack of direct energy flow studies, estimates of gross production to community respiration ratios, net community

production, and the nature of aquatic food chains can be obtained from (1) a knowledge of the species composition, and (2) from chemical analyses of the effluents entering the waterways from urban, wastewater treatment plants, industries, and from septic tank drainage.

(2) Indicators of Community Energetics for Terrestrial Zone

The energetics of terrestrial ecosystems can be estimated indirectly from a knowledge of the ecological successional status of the region in question. In the Three Rivers Watershed the deciduous forest is the most stable, long-lasting (climax), terrestrial ecosystem possible under the prevailing climatological conditions. At present, mature deciduous forests cover less than 10 percent of the basin. Early successional types of vegetation cover most of the unmanaged watershed.

The following successional stages occur in terrestrial portions of the Three Rivers Watershed: (1) urban-industrial; (2) croplands harvested annually; (3) permanent pasture and managed grasslands; (4) shrub-early successional woodlands; and (5) mature woodlands. Acreages covered by each of these zones can be estimated from aerial photographs.

b. Community-Structure

Community-Structure refers to the variety and quantity of the biotic and abiotic components within an ecosystem. These include the concentration of various inorganic nutrients, organic compounds, and the kinds and relative abundance of producers, consumers and decomposer organisms. The stability of an ecosystem depends

on the kinds of organisms present (species composition), the spatial distribution pattern of organisms (solitary or grouped) and the organization of species into distinctive communities.

Community-structure in most ecosystems is extremely complex and difficult to analyze. To circumvent these difficulties, a variety of biological diversity indexes or species diversity indexes have been developed. Species diversity indexes are ratios of the number of species to certain importance values, such as number, biomass, or productivity. Many diversity indexes have been proposed and some have been used extensively to describe community structure.

The variety or diversity of species tends to increase as ecosystems mature. Also the assemblage of organisms becomes more organized and stratified into characteristic patterns in older, more stable ecosystems. Alteration of the physical environment reduces biological diversity, thereby, destroying stratification patterns and creating less organized and more unstable ecosystems.

Indicators of Community-Structure. The distribution and concentration of inorganic nutrients, the diversity of species and the degree of community stratification and pattern diversity can be obtained from species inventories and from chemical-physical surveys of the soil and water. Most ecological studies conducted within the Three Rivers Watershed have focused on some aspect of community-structure.

c. Life History

Life History refers to the various developmental stages through which organisms pass during their lifetime. These stages in development are often accompanied by changes in food habits, body size and appearance, habitat preference, and niche requirements.

As ecosystems mature, organisms with longer and more complex life cycles form an important part of the community. In early stages of ecosystem development, the organisms are small with simple life histories and rapid rates of reproduction. The change to larger organisms in mature ecosystems is related to a shift from inorganic to organic nutrients. Small organisms with a larger surface to volume ratio are able to utilize inorganic nutrients more efficiently than large organisms. Niche specialization and the average size of organisms increases in mature ecosystems.

Disturbances in the physical environment that release large quantities of inorganic nutrients into the system favor the smaller organisms and convert the ecosystem to a more unstable, early developmental stage.

Indicators of Life History. An index of the niche specialization, size of organism, and the type of life cycle can be obtained from species inventories and from a knowledge of the life histories of the dominant organisms. Except for microorganisms this information is well known for most plants and animals inhabiting the Three Rivers Watershed.

d. Nutrient Cycling

Nutrient Cyling refers to the flux of major elements such as nitrogen and phosphorus between the biotic and abiotic components of an ecosystem. Mature and stable systems, as compared to young or disturbed ecosystems, have a greater capacity to retain nutrients within the system. Nutrient cycles tend to be closed and the nutrients entrapped in the biotic rather than the abiotic components of mature, healthy ecosystem.

Indicators of Nutrient Cycling. For aquatic ecosystems, nutrient exchange rates between organisms and the environment, and the role of detritus in nutrient regeneration can be estimated from chemical and physical water quality data. For terrestrial ecosystems various aspects of nutrient cycling can be estimated from the successional status of the terrestrial vegetation, from soil analyses, and from chemical analyses of ground water.

e. Selection Pressure

Environmental changes, both biological and physical, that create conditions favorable to one organism at the expense of another, are known as selection pressure. Species with high reproductive potential and high growth rates are more successful in young, developing ecosystems. As the ecosystem becomes more crowded, selection favors species with a lower growth potential, but better suited for competitive survival. Disturbed ecosystems frequently experience large outbreaks of nuisance organisms such as mosquitoes and black flies. Disease organisms also spread more rapidly in disturbed or unstable ecosystems. The quality of life is emphasized in the long-term strategy of ecosystem development rather than productivity of vast numbers of a few species.

<u>Indicators of Selection Pressure</u>. The growth-form of aquatic and terrestrial communities can be estimated from quantitative species surveys. While a number of species inventories are availabe for the Three Rivers Watershed, very few contain quantitative information.

f. Homeostasis

Homeostasis is the ability of an ecosystem to control with minimum disruption to its structure the effects of outside disturbances. In mature ecosystems, the net result of interactions among organisms is an increase in symbiosis, nutrient conservation, stability, and organization. Ecosystems evolve toward as large and complex structure as possible within the limits set by the energy available and the prevailing physical conditions.

Various forms of species interactions such as mutualism, parasitism, predation and commensalism assume greater and greater importance as ecosystems mature and reach equilibrium. These interactions increase the ecosystem's control over external factors and contribute to the overall stability of the system.

Disruption of species interactions upsets established equilibria and interferes with the ecosystem's ability to control nutrient flow, retain its structural configuration, and resist external physical and biological forces.

Table 1. Attributes or parameters that can be used to characterize the degree of stability, maturity or "health" of an ecosystem.*

(1) Ecosystem parameter	(2) Unstable or developmental stages	(3) Mature or healthy stages	(4) Priority
(1) Community energetics			
a. Gross production/ community respiration (P/R ratio)	Greater or less than 1	Approaches 1	5
b. Gross production/ standing crop (P/B ratio)	high	low	16
c. Biomass supported/ unit energy (B/E ratio)	low	high	17
d. Net community production	high	low	18
e. Food chains	linear - predominantly grazing	weblike - detritus	19
(2) Community structure			
f. Inorganic nutrients	extrabiotic	intrabiotic	3
g. Species composition	Species tolerant to wide range of conditions	Species with narrow tolerance limits	1
h. Species diversity - variety	low	high	2
i. Species diversity - equitability	low	high	4
j. Stratification and spatial heterogenity (pattern diversity)	Poorly-organized	Well-organized	20

Table 1. Continued

	(1)	(2)	(3)	(4)
		(3) Life History		
k.	Niche specialization	Broad	Narrow	12
l.	Size of organisms	small	large	13
m.	Life cycles	short, simple	long, complex	14
		(4) Nutrient cycling		
n.	Mineral cycles	open	closed	7
o.	Nutrient exchange rate between organisms and environment	rapid	slow	8
		(5) Selection pressure		
p.	Growth form	rapid, "J" form	feedback control "S" form	9
q.	Production	quantity	quality	15
		(6) Overall homeostasis		
r.	Internal symbiosis	underdeveloped	developed	10
s.	Nutrient conservation	poor	good	6
t.	Stability (resistance to external perturbations)	poor	good	11

*Adapted and modified from E. P. Odum in Science, 164:262-270, April 18, 1969. Copyright 1969 by the American Association for the Advancement of Science.

Table 2. Major ecosystems in the Three Rivers Watershed of Northeastern Ohio.

Type zones	Ecosystem: Terrestrial (aerial: soil: sub-surface)	Ecosystem: Aquatic (aerial: sediment: sub-surface
Unmanaged		
	Mature Forests	Streams
	Early Successional Woodlands	Rivers
	Old Fields	Natural Lakes
		Swamps
		Reservoirs
		Ponds
Managed		
	Perennial Cropland	
	Annual Cropland	
	Urban - Industrial	

5. An Ecological Inventory

To enable a consideration of the primary impacts of the technology, down to specific process components, a more detailed checklist of ecological characteristics was prepared. These characteristics were divided into aquatic, terrestrial, sub-surface and atmospheric effects, and further subdivided with descriptive examples of possible impacts.

1. Aquatic Zone

a. Ohio Water Quality Standards

- Bacteria, temperature, pH, odor, radioactivity, dissolved oxygen, dissolved solids
- Specific chemical constituents including: arsenic, barium, cadmium, chromium, cyanide, fluoride, lead, selenium, and silver
- Putrescent and objectionable sludge deposits
- Floating debris, oil and scum
- Nuisance odors or colors
- Substances harmful or toxic, animal, plant or aquatic life
- Stream flow maintenance, diversion, impoundment

b. Species Diversity

- Aquatic benthic invertebrates
- Dominant vascular plants
- Soil invertebrates

c. Species Composition - Aquatic Ecosystems

- Coliform bacteria
- Benthic invertebrates
- Algae
- Fish

d. Nutrient Cycling and Storage

- Phosphorus, nitrogen cycling
- Eutrophication

e. Drainage--Run-off

- Related to infiltration rates, farming practices
- Sedimentation levels, turbidity
- Storm loadings, run-off controls
- Stormwater constituents; pollutants

f. Insolation

- Related to rate of eutrophication, plant growth, lake inversion, decay factors, purification effects

2. <u>Terrestrial Zone</u>

a. Species Composition - terrestrial ecosystems

- Dominant vegetation
- Dominant vertebrates
- Soil invertebrates

b. Surface Water

- Question of disposal of effluent
- Secondary uses, reuse--ground water recharge, stream augmentation, heat sinks for power production, other cooling purposes, use in industrial production

c. Soil

- Sludge disposal--high nitrogen, phosphorus, low potassium, trace metals concentrated, pathogens can be present
- Accumulation of toxic materials
- Biomagnification in biota of soil layer, soil invertebrates
- Erosion and sedimentation factors
- Soil chemistry--impact of applied solutions, organic complexing, ion exchange and clay adsorption of heavy metals
- Salinization of effluent, sub-soils, ground waters
- Osmotic pressure changes, related to TDS--plant deficiency
- Potential rehabilitation with sludge

d. Soil Permeability

- Relationship of sodium ion to breakdown in soil structure and decrease in permeability
- Long term effects of application on infiltration and percolation related to permeability and life of the land filter
- Initial percolation rates
- Other characteristics: fertility, texture, intake, holding capacity, drainage, slope

e. Plants

- -Variable crop productivity--forest, forage, agricultural
- -Extended growing season due to heated materials
- -Biomagnification in plants--uptake of metals, toxins--concentration of selenium, molybdenum
- -Deposition by evaporation of pathogens, toxicants on leaves, etc.
- -Reliability of crops for removal of nutrients
- -Biological changes in soil system, soil bacteria--question of negation of soil bacterial action by excess chlorine
- -Alternately an acceleration of bacterial action and reduction of surface organic matter (related to complexing of metals)
- -Changes in plant species composition
- -Growth changes in relation to wetter ecosystem in spray areas
- -Saturation problems--denial of root aeration

f. Animals

- -Water related insect growth
- -Animal population, diversity
- -Species composition, dominant organisms

3. <u>Sub-surface Zone</u>

a. Ground Water

- -Impact in spray areas on ground water mound originating at center of irrigation site, possibility of control of ground water table and percolate by under-drainage
- -Ground water chemistry--dissolved constituents to local system, such as sodium, potassium, chlorides, nitrates, phosphates, heavy metals
- -Question of migration of dissolved constituents in land system--salinization
- -Question of alteration of ion exchange and sorption processes to reduce transmissibility of subsurface materials
- -Biological attenuation in sub-surface
- -Quantity--loss of aquifer recharge by transfer from river basin vs. increased recharge in irrigation areas
- -Quantity--reduction of recharge due to the urbanization encouraged by new sewer systems
- -Need for make-up of surface water due to loss from basin, water demand increase due to quality improvement, population increase
- -Recharge with waste water--quality questions
- -Question of leachate from landfill disposal of sludge ash--strongly basic mineral compositions, localized sulfates, chlorides

b. Deep Well Disposal

- Ultimate disposal policies
- Geology--potential for aquifer pollution, earthquakes

c. Mining Resources

- Denial of access to prime sand and gravel deposits

4. Atmospheric Zone

a. Incineration-Combustion Products

- sludge incineration--oxides of nitrogen and sulfur, particulates, carbon monoxide related to temperature and organic content, volatilization of mercury at 300^{o}F
- Power production related to treatment process--air pollution

b. Aerosols

- Related to spray irrigation, viral content

c. Humidity

- Evaporation--transpiration
- Micro-climate changes, fogging

d. Decomposition Products

- Anaerobic decomposition--hydrogen sulfide, methane, malodorous organics
- Physical-chemical by-products, ammonia stripping

C. Public Health Parameters

Parameters in this area were developed through an exhaustive search of available literature and discussions among governmental and major private agencies in the area and at the state level. So many factors were uncovered relating to public health that in the interest of brevity and conciseness we present them in the form of a checklist.

1. Biological Agents -- Pathogens

a. Water-borne

-Bacteria, Spirochaetes--regrowth conditions
-Protozoa, parasites--chlorination resistance, motility
-Viruses
 -major pollutant hazard in water reuse
 -primarily human in origin
 -detection methods insensitive and inaccurate
 -endemic occurence of water borne viruses--sources of chronic crippling diseases, slow viruses
 -low infectious dose--incidence of subclinical illness
 -advanced treatment may facilitate bacterial multiplication

b. Vector-borne

-various pathogenic agents--tularemia, encephalitis
-related to increase in animal habitat, pool of wildlife disease hosts
-increase in arthropod vectors, blood sucking insects
-malarial transfer, pesticide resistant mosquito populations
-related with ponding, solids disposal

c. Aerosols

-aerosols downwind of seage plants, disposal areas
-evaporants, agricultural dusts, fungi, bacteria
-emission from air-water interface--lake waves

2. Toxic Agents

a. Organic Toxicants

-pesticides, herbicides, fungicides, detergents, phenols, surfactants, algal phytotoxins
-organic carcinogens--polyaromatic hydrocarbons
-mutagenesis, teratogenesis and chronic degenerative disease
-biologically refractive agents
-biostimulants (DES)

b. Inorganic Toxicants

-nitrites, nitrates--infantile methemoglobimemia, soil concentration

-dental fluorosis - fluorine
-water hardness--relation to cardiovascular diseases
-metals: Cadmium, lead, arsenic, barium, copper, beryllium, silver, nickel, zinc, chromium, cobalt, mercury, selenium, molybdenum, tin, manganese, vanadium, antimony, strontium
-acids and salts--cyanides and sulfides
-chlorides, sulfates and dissolved solids
-ammonia compounds
-irritants (mineralization, causticity)
-can repeated reuse of effluent lead to mammoth salt concentrations--750mg/l and above
-corrosion, runoff, aerial fallout, additives used in water treatment contribute to total pollution

3. Radioactive Contaminants

-concentrations of radionuclides, biomagnification
-Strontium 90, other long-lived isotopes
-relationship to water cooling and stack emission in nuclear power plants, hospital and industrial wastes

4. Biomagnification

-primary concentration by planktons
-biochemical conversion-inorganic to methyl mercury by microorganisms
-shellfish-concentration of metals, radioactives
-in food harvest from rivers and lakes
-food and fiber production using wastewater
-increase in soil biota--earthworms and small arthropods in food chain
-if crop not edible, how dispose
-organometallic compounds (chlorides, phosphates)
-polychlorinated biphenyls (PCB)

5. Synergistic Effects

-chlorinated phenols, herbicides converted to dioxins in wastewater processing, increased toxicities
-chlorine disinfection converts parathion to paraoxon
-increased toxins by biologic degradation
-collective, cumulative and antagionistic effects
-chloramines, chlorphenols production
-release of mercury from sediments by deicing salts
-heat reaction--bacterial growth environment
-nitrates reaction with secondary amines--notrosamines
-potentiation of metals toxicity by NTA, EDTA, etc.

6. Reliability

-plants not fail safe
-subject to mechanical breakdown--shock loading
-less than critical toxicity--biological process poisoned
-land disposal requires constant hydraulic infiltration rate
-breakdown in under drainage

-pipeline failure--leakage
-diurnal variations in flow--adjustment in treatment process
-finite renovation capacity in soil--life span
-inefficiency, extended failures, power outages, bypassing
-provision of standby units, holding basins, alternate disposal methods, fail safe monitoring

7. Recreational Hazards

-water borne, water associated enteric infections
-upper respiratory, eye and ear infections
-ingestion of toxic algae, fungi, actinomycetes and their toxins
-ingestion of toxic chemicals--air-water interface
-dermatitis of schistosomes, algae and bacteria
-eye irritations related to pH, buffering capacities, etc.
-accident hazards due to impaired visibility underwater (suspended materials), slippery bottom conditions caused by excessive growth of slimes and weeds, surface and underwater debris
-oxygen demanding wastes--anaerobic conditions, noxious waste products

8. Solids Disposal

-hygienic risk, primary and secondary reduction concentrates in groundwater
-increase in rodents, vermin, insects, vectors
-viral concentrations
-leachate products--groundwater contamination
-translocation of pathogens to sludge--concentrations
-septic tank disposal
-incinerator products--volatilization of mercury--other metals
-sulfur dioxide, nitrogen oxide, stack pollutants

9. Crop Disposal

-use by humans or animals--is it usable
-selenium and molybdenum uptake in plants
-evaporation of effluent on plant leaves--concentration
-toxicant absorption--roots and leaves
-transport in soils--through plants into animal and human food webs
-question of pathways, retention and toxicity of metals in soils, plants, and animals
-disposition of animal waste if crop is used for feed

D. ESTHETIC PARAMETERS

The esthetic parameters encompass potential impacts of wastewater management systems and improved water quality on human sensory perceptions, including visual, olfactory, taste and preferential considerations. This is an especially difficult area of assessment, in that esthetics, by definition, relate to the value orientation of human response and those values are not easily measured. Preliminary criteria must specify what is to be considered as an esthetic benefit in the impact of water resources on human sensory perception.

Generally, the value of water as an esthetic resource can be defined as its input to the overall landscape appearance. Water is a dominant visual resource of the landscape which is best realized in relationship to compatible contiguous land development.

The esthetic impacts of alternative wastewater management systems derive directly from the location, scale and design of physical components of treatment facilities and from the changes in quality of effluent. The quality of natural water bodies, the particular reuse potentials of the effluent and effects on user activity patterns present esthetic implications for the interrelated environmental components of water, land, air, biota, and the general regional image.

Although esthetic impacts are assumed to be of lower relative importance than the other impact areas, this should not over shadow the significance of esthetic implications. It must be noted that the esthetic impacts are indirectly derived from considerations evaluated under the ecological, hygienic, social opportunity and economic areas of concern. The parameters here specified as esthetic impacts must be assessed from a cost/benefit perspective on the one hand, in terms

of trade-offs against other objectives, while on the other hand, considering the potential compatibility of those objectives.

1. Water

   a. Physical Characteristics of Water

      -clarity, color, turbidity, odor, taste, temperature (suspended materials, algae, organic substances, metallic and non-metallic ions, decay products)

   b. Surface Characteristics

      -oil, debris, siltation, scum, foam, froth

   c. Water Movement

      -stream flow, stagnancy, water falls

   d. Plant Growth

      -algal blooms

2. Land

   a. Land Use

      -effect on open space, forest, agricultural land, urbanization
      -net acreage changes

   b. Conservation of Existing Landscape

      -retention of visual patterns, esthetic stability
      -preservation of regional character
      -perceived historic and scenic features, effect on residents' perception and symbolism of the land (quality of life)

   c. Land Reclamation

      -improvement of marginal agricultural land, strip mine areas
      -enhancement of environmental quality, land fill areas
      -septic tank discharges

   d. Compatibility of Landscape Changes

      -need to mute visual symbols of waste disposal facilities
      -subordination of new structures, roads, channels, ponds, lagoons to natural contours, screening
      -multiple use of facilities (parks)

e. Recreational Opportunity

-opportunity to create new environment designed for leisure travel, visual patterns
-diversity of recreation
-access availability for various publics

f. Disruption of Environment

-changes in access, convenience, appearance during construction
-route of least social cost for pipelines

3. Air

a. Air Pollution

-smoke (nitrogen and sulfur oxides), odor, particulates etc., produced by sludge incineration
-power generation related to disposal and pumping requirements
-regeneration of process constituents

b. Odor Effects

-associated with plant operations, holding basins, spray areas, organic decay, anaerobic conditions
-hydrogen sulfide, methane, etc.
-changes to wetter ecosystem

c. Ecosystem Changes

-changes in micro-climate, haze, localized fogs, due to spray irrigation
-changes to wetter ecosystem

4. Biota

a. Nuisance Organisms

-algae, phraetophytes, unrooted aquatic plants, insects, rodents, rough fish

b. Wildlife Habitats

-wet land sanctuaries
-water associated bird and animal life
-endangered species

c. Flora and Fauna

-increase in desirable aquatic plants, fish, etc.
-vegetation complementary to river scope

5. <u>Other</u>

a. Regional Image

-enhancement of regional image
-changes in perception of area

E. SOCIAL WELL-BEING PARAMETERS

The development of the social well-being parameters was guided by guidelines from the Office of the Chief of Engineers (18 June 1971) and by the evaluation team's experience and judgment. OCE defined the prime sociological concern as the preservation and enhancement of intra- and inter-community relationships essential to community viability and integrity. Its guidelines placed emphasis on (1) conveniences of community residents, (2) community or individual values, and (3) human betterment and education. The evaluation team's criteria were essentially the same but were expressed in terms of maximizing individual growth and community development.

In developing the social well-being parameters, consideration was given to established social goals for the Northeast Ohio region. Due to the relative lack of regional awareness, the fragmentation of political structures and planning bodies, and the inactivity of the Northeast Ohio Areawide Coordinating Agency, explicit social goals for the region were not available. Social goals are implicit in the Northeast Ohio Water Development Plan and other public statements. Many of these had yet to be presented to their various constituencies at the time of the study and none of them had the benefit of broad-based regional consensus. In the absence of specific goal statements we assumed a general goal of maximizing individual growth and community vitality. In selecting parameters we tried to answer this question, "Will water management advance regional, community, or other subsystem goals and aspirations in terms of (1) economic opportunity, (2) political opportunity, (3) individual freedom and opportunity, (4) collective security and

survival, (5) recreational opportunity, and (6) educational opportunity?" Parameters were developed for each of the social well-being components numerated above. Flows of benefits and costs to persons and groups should be traced to check for possible unintended consequences of wastewater management on this scale.

1. Economic Opportunity, the first component.

Under this component we examine the effects of the alternative plans on the basic needs of particular groups of people in the region in terms of income distribution and revenue generation.

Parameters:

a. Distributive equity. Which groups benefit most/least from current water management practices and which benefit most/least from proposed alternatives. Can more benefits go to those persons or groups with greatest needs and least resources?

Criteria: Distribution of real family income across a variety of publics. Publics to include populations served by each alternative plan; populations displaced or severely impacted; neighboring populations; populations otherwise affected (recreational groups, tourists, water consumers, etc.).

Indicators:

(1) Distribution of income (per capita income levels).
(2) Stability of income (seasonal fluctuations, changing markets, etc.).
(3) Price stability (low rent areas, land values, product and service costs).
(4) Degree of change in job mix and potential for job change (rural counties, inner cities, etc.), i.e. marginal farmers to municipal employees.
(5) Change in tax structures.

b. Revenue development. Which plan maximizes return on public investments in wastewater management thus reducing costs to public. Which plan offers best possibilities for public-private, government-industry, cooperation--returning revenue to public sector?

Criteria: Joint concern with processing of raw materials, production of goods, and reclamation of residuals to reduce "wastes" and "pollutants." Shift in user charges proportionally to larger consumers.

Indicators:

(1) Number of government-industry cooperative ventures (joint sitings, cooperative industrial waste treatment, etc.).
(2) Variety of revenue producing activities and estimated incomes (dumping fees, location fees, effluent charges, resource charges, solid waste disposal fees, sale of agricultural and aquacultural products).

2. Political Opportunity, the second component.

We examine citizen and consumer participation in political processes associated with planning for better wastewater management. The goal is to maintain or increase community integrity and individual competence.

Parameters:

a. Equality of political opportunity. Which groups participate in decision-making regarding current water management practices. Can class differences be taken into account: e.g., the lower class emphasis upon a sense of place or territoriality, the middle class values of low population density and physical appearance of neighborhoods? Do the alternatives lend themselves to easy presentation and understanding by the publics involved?

Criteria: Distribution of information and participation opportunities across a variety of publics. Adequacy and use of communications media. Care taken not to overwhelm decision-makers with technical details.

Indicators:

(1) Degree and nature of citizen and consumer participation (who, how often, in what form).
(2) Costs of participation (transportation, distance, time).

b. Institutional Change. Increased community cooperation. Promotion of unified environmental programs across urban-rural, county, metropolitan-regional boundaries. Total waste management approach.

Criteria: Which alternatives lend themselves most readily to inter-governmental cooperation. Types of institutional arrangements possible (sewage districts, county governments, etc.). Acceptability to other governmental units.

Indicators:

(1) Number and type of intergovernmental water management or related projects.
(2) Degree of acceptance or rejection of alternatives by governmental units (particularly those receiving wastes).
(3) Impact of alternatives on social programs of other federal, state or local agencies (OEO, Model Cities, HEW, welfare, etc.).

3. Individual Freedom and Opportunity, the third component. We study opportunities for individual growth and initiative, the satisfaction of physiological needs, safety needs, self-esteem and self-actualization. The goal is to maximize freedom of choice, movement, expression, and individual accomplishment.

Parameters:

a. Freedom of choice, movement, and expression. Complex environments emit numerous messages to their human inhabitants and elicit complex behavior. The individual has degrees of freedom to perform within these environments depending upon his perceived possibilities for functioning. Societal constraints guide his functioning toward achievement of social goals.

Criteria: Existence of alternatives and constraints. Diversity of environments. Choice of goods, foods, and services. Alternatives in types of water available (distilled, spring, non-flouridated, soft, etc.). Patterns and composition of consumption.

Indicators:

(1) Proximity of water-based or other recreation to residences.
(2) Population density
(3) Proportion and location of open land.
(4) Variety and extent of legal restrictions (private property rights, water rights, restricted usage, single purpose usage, etc.).
(5) User charges and costs.

b. Individual security. Freedom from stress, (a function of the individual's position in the needs hierarchy). Causes of stress are physical, environmental, economic, and psychological. Related to perception of impact of water pollution problems on one's life.

Criteria: Distribution of stressors (noise, visual blight, chemicals, population density, sense of territoriality, etc.) across publics affected.

Indicators:

(1) Degree of community and personal displacement.
(2) Degree of economic violence (inequities).
(3) Degree of social violence (discrimination).
(4) Degree of physical violence.

4. Recreational Opportunity, the fourth component.

This component is concerned with the variety, quality, availability, and distribution of recreational benefits for the general public.

Parameters:

a. Variety and diversity. What kinds of recreation are available to which publics.

Criteria: Identification and classification of recreational alternatives.

Indicators:

(1) Number and categories of water-related recreational alternatives.
(2) Distribution of water of quality suitable for full-body contact recreation.

b. Equality of recreational opportunity. Which groups benefit most/least from current water-related recreation; which will benefit most/least from alternatives.

Criteria: Distribution of recreational alternatives across a variety of publics and participation patterns.

Indicators:

(1) Participation levels of selected groups.
(2) Participation costs for selected groups.

c. Ease of access to and availability of recreation. Proximity of recreation sites to residences. Availability of convenient and cheap transportation.

Criteria: Distribution of recreational opportunities relative to population density and transportation networks.

Indicators:

(1) Number of recreational opportunities per 100,000 population.
(2) Population density and location.
(3) Availability of transportation facilities.

5. Collective Security and Survival, the fifth component.

We assess the impact of regional wastewater treatment upon the survival of man as a species and upon the health and environmental security of populations within the region. We also consider internal and external security.

Parameters:

a. Internal security. Will the construction of facilities or related activities so alienate some groups as to lead to breakdown in community cohesiveness and increased likelihood of violent acts--individual, mob, revolutionary, or subversive.

Criteria: Threats of violence and acts of violence against facilities or personnel. Lawsuits filed, injunctions sought, other legal measures. Demonstration picketing, boycotts.

Indicators:

(1) Number of acts of harassment or violence.
(2) Number of legal actions filed or sought.
(3) Size and nature of publics opposed to or supporting a given alternative.
(4) Dependence of plan upon a single technology or major facility.

b. External security. Effects of large scale wastewater treatment on alliances and international agreements.

Criteria: Will plans violate provisions of U.S.-Canada agreements on Great Lakes Basins or other international environmental agreements (U.N.).

Indicator:

(1) Volume of water gained/lost from Lake Erie under alternative plans.

c. Health security. Detection of health hazards; prevention of water-borne diseases; occupational safety; knowledge of public desires as popular and legal definitions of pollution change.

Criteria and Indicators: See discussion of Public Health.

d. Environmental and species security. Awarness of environmental problems among those who had adapted to them and take conditions for granted. Diversity of treatment technologies to prevent putting a stranglehold on the future. Improvement in air and water quality and land use.

Criteria: Dissemination of information on key factors in wastewater management to public. Reduction of pollutants through design and management. Variety in technologies (applying Ashby's law of requisite variety).

Indicators:

(1) Degree of support for wastewater treatment in sensitive areas (inner cities, rural).
(2) Diversity of technological solutions incorporated into managment systems.
(3) Air and water quality.

6. Educational Opportunity, the sixth component.

We examine the effects of wastewater managment on the educational needs and experiences of selected publics in the region in terms of quality, variety, and opportunity.

Parameters:

a. Quality and variety in education. Changing tax structures or revenue sources associated with public investment in and construction of a regional wastewater managment system will have direct or indirect effects on the financing of education. The facilities themselves can augment educational programs in a variety of ways.

Criteria: Lessening or augmentation of education revenues in selected locales. Evaluation of possible program benefits associated with alternatives.

Indicators:

(1) Potential for augmentation of educational programs and facilities.

(2) Potential for research programs on water management and related subjects in association with educational institutions.

b. Equality of educational opportunity. Can change in revenues and tax structures through public investment in Wastewater management distribute educational benefits in a more equitable fashion.

Criteria: Distribution of income and financial aid across a variety of publics. Availability of facilities.

Indicators:

(1) Potential for providing more equitable distribution of financial aid to school districts.
(2) Proximity of environment-related education facilities to users.
(3) Availability of transportation to environment-related educational facilities..

F. ECONOMIC PARAMETERS

The following parameters were developed in this category:

1. <u>Direct Cost of Project</u>

   a. Capital Costs

   -Total cost of new construction, treatment plants, pipelines, pumping stations, irrigation facilities, plant life span
   -Flexibility - ability of the system to respond to technological change without obsolescence, incorporate new developments, related to sunk costs; capability to adjust to peak or seasonal loadings, increased loadings due to growth; capability to adjust to higher quality standards

   b. Operation and Maintenance Costs

   -annual, per capita, per million gallons
   -utilization factors
   -economy of scale, recycling, recover, user charges

2. <u>Indirect Costs of Project</u>

   a. Cost Impact on Industry

   -Cost of pollution control and benefits of improved water quality for water using industries (cost of corrosion, wear, equipment cleaning, in-plant water treatment)

   b. Cost of Municipal Water Supply

   -Related to source and cost of procurement and treatment required to produce drinking water quality recharge of ground water, discharge to headwaters, interbasin transfer)

   c. Loss of Mineral Resources

   -Loss of sand and gravel deposits, other mineral resources due to flooding, irrigation

   d. Flood and Erosion Costs

   -Possibility of increased flooding due to increased return to river basin, increase in flow, erosion consequences

   e. Water Loss

   -Loss of water to system due to pipe loss, irrigation and evaporation, diversion

3. Land Use

a. Residential, Commercial

-Sewage treatment expansion, land development pressure, land use controls, changes in land values, desirability

b. Industrial

-Land vacancies related to pollution control costs in marginal industry; bankruptcies and plant removals, new industrial attraction related to available treatment

c. Institutional

-Locational decisions related to residential development, obsolescence of current treatment facilities--abandonment, expansion

4. Power Supply

a. Cost and Availability

-New power demand for wastewater treatment and transportation, cost, changed use patterns, air pollution controls

b. Power Plant Location

-Relationship of conventional or nuclear plants to cooling capacity in wastewater lagoons

5. Redistributive Effects

-Distribution of costs and benefits, secondary effects

6. Employment Effects

-In construction and operation, industrial attraction, multiplier effects, agricultural changes

7. Change in Property Values

-Related to improved water quality, location of wastewater treatment facilities and areas, agricultural land, competition among uses

8. Effect on Tax Base

-Related to government take-over of large land areas for filtration

9. <u>Effect on Recreation</u>

-Availability of alternative recreational opportunity particularly related to immobile and disadvantaged
-effect on recreational industry, diversification

10. <u>Change in Industrial Mix</u>

-Possible changes in industrial diversity
-Effect on agriculture related to land reclamation, yield improvement, denial of access to or requirement of crop changes on agricultural land, lessening of fertilizer demand, long term deterioration of land due to accumulation of waste products
-Effect on commercial fishing related to quantity, quality, production (spawning areas and hatch capability), edibility (concentration of toxicants)

11. <u>Project Induced Disruption</u>

-Related to physical space, construction, pipe installation, disposal areas

12. <u>Fiscal Capacity and Effort</u>

-Ability and willingness of area to support wastewater treatment

G. INSTITUTIONAL-POLITICAL PARAMETERS

Political feasibility and institutional resistance or accomodation are major considerations in the social arena that will dictate whether a watershed plan becomes a physical reality or remains as a sterile recommendation. While these characteristics are contained in the general social well-being parameters, a reiteration with political emphasis was considered essential.

1. Bureaucracies

a. Bureaucratic Change--Stability

- -Changes in bureaucratic power and prestige
- -Acknowledgement of current political systems, alignment and leadership--local, county, regional
- -Vested interests in current plants, systems and technologies
- -Perception of opportunity in new technology and management
- -Effect on water-related technicians and agencies
- -Changes in control of policy and resources
- -Institutional realignment needed to control major system

b. Intergovernmental Relations

- -Requirement for more intergovernmental coordination
- -Effect on multiple government isolation, autonomy, perogatives
- -Support or impetus to regional organization, cohesion, planning

c. Legislation

- -Requirement for new state legislation of varying scope
- -New administrative organizations
- -Substate regions
- -Enabling legislation

d. Skills, Professions

- -Professional manpower requirements for system operation--adequacy, availability
- -Substitution of new skills, obsolescence, turnover
- -Training and retraining requirements

2. <u>Citizen Involvement</u>

a. Tax liability--perception related to:

-level of local taxation, bonds, assessments
-amount and ease of obtaining federal and state aid
-front end costs
-user charges, distribution, fairness
-outstanding indebtedness on existing systems to be closed
-"waste" of current plant and capacity
-least cost alternatives

b. Political Access

-change in individual and group access to water and health-related bureaucracies
-public perception of opportunity for role in decision-making, feedback
-anxiety, mistrust related to outside intervention in community
-informational access
-public perception of Corps image (environmental indifference)

3. <u>Regulatory Control</u>

-need for increased control to meet water quality standards
-need for monitoring of operating bureaucracy and of technology (plants, systems)
-penalization of violations
-land use restrictions, zoning changes required
-limitation of discharges, individuals, municipalities, industries
-drainage controls, erosion, sedimentation
-control of urbanization by utility extension or denial
-restrictions on individual conduct
-perceptions of restriction on freedom, individual conduct
-control of agricultural products, uses

4. <u>Community</u>

a. Community Disruption

-loss of property tax base by government acquisition
-loss of income, sales taxes from dislocation
-changes in social, business patterns, scale, from loss of residents
-loss of residents and leadership skills
-construction damages, pipeline easements, neighborhood disruption

b. Community Identity

-effect on visual personality of community, region
-disruption of historical, cultural, recreational attributes of community
-effect on what residents think of community and self image, deterioration

5. Resident Disruption

a. Inconveniences

-changes in access to open space, recreation
-changes in water use rights, access
-disruption to existing activities
-ease of adaptation to new conditions
-access to resources and services
-changes in diversity of recreation (loss of game, increase in swimming, etc.)
-pipeline easements--barriers to social, physical interchange
-new access to corridors, recreation trails
-disruption of traffic patterns

b. Dislocation

-displacement by plant construction, taking of irrigation lands
-loss of homestead, livelihood
-changes in life style, economic stability, transportation
-losses in relocation, forced sale, less than fee acquisition

H. PRIORITY PARAMETERS FOR THE CLEVELAND-AKRON METROPOLITAN REGION

The exhaustive search for possible parameters in each of the categories of evaluation generated a very extensive list. It was beyond the capabilities of the evaluation team, because of resource constraints, to conduct impact assessments for each of the parameters developed. Our intent at the beginning of the study was to do a conventional impact assessment. However, so many questions regarding the adequacies of the technologies themselves arose that time and again we found ourselves probing design factors rather than doing impact assessment. In addition, the scale of the regional system forced us away from pinpoint assessment, e.g., the effects of outflow from a given steel plant, to categorical evaluation, e.g., the effects of industrial contaminants upon the general biota of a given river or basin. We concentrated heavily on the ecological, public health, and economic categories to the detriment of the esthetic and social well-being categories. We discovered that a hierarchical principle applicable to the order in which human needs are met also applies to social system needs. Only to the extent that fundamental public health and ecological factors are favorable can other amenities such as esthetics and certain aspects of social well-being become salient.

Certain fundamental problems in large scale application of advanced wastewater treatment procedures whether of the biological, physical-chemical, or "living soil filter" variety also mandated a concentration on ecological, public health, and economic parameters. Projection of present trends with regard to wastewater treatment

technology in the target region revealed a massive and perhaps unalterable commitment to biological-physical-chemical processes with water disposal of effluent. Given a system virtually locked into this technological pattern, the overriding question at this point in time must be whether this technology is as sound in terms of ecological and public health impacts as alternative technologies.

These necessities made us modify our evaluation and be highly selective in our emphasis. Considerable attention was paid to ecological parameters with particular attention paid to a resource demand component and a hydrologic effect component. In addition, residuals from each of the treatment designs were stressed because of the secondary effects they create upon the environment. In the public health category considerable attention was paid to the efficiency and reliability of the various processes as well as their flexibility. Stormwater management and disposal of residuals cut across both ecological and public health categories, as well as having some economic relevance. In the social well-being category particular attention was paid to land use changes and to political/public perceptions regarding acceptability of various treatment processes.

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IV. REGIONAL PLANNING OBJECTIVES

A. BASIC REGIONAL PROBLEMS

The identification of regional planning objectives requires an awareness of the basic problems of the study area and of the constraints that prevent the attainment of a more optimal condition. The problems are, to a large extent, those associated everywhere with urbanization but with certain emphases and added facets that are peculiar to the region. Additonal difficulties are introduced by a growing lack of consensus on the direction of progress. At this point in American history, many of the traditional objectives related to economic growth are being challenged by those who see the quality of life diminished and the total environment degraded by this philosphy and who would call a halt to expansion.

The main problems and constraints of the Cleveland-Akron metropolitan area are readily classified, but their relationship to wastewater management is varied. The impact of alternative wastewater management systems will be most visible in certain aspects of the natural environment, but more distant, secondary effects can occur in related elements. It must be noted that the developing trends in the region may seriously affect the realization and significance of a comprehensive wastewater management program. The unfavorable characteristics are probably best categorized under three main headings: Environment, Land Use, and Socio-Economic Structure.

1. Natural Environment

   a. Unfavorable climate relative to competitive regions for attraction of industry.

b. Topographic constraints on urban development found in dissecting valleys and steep slopes.

c. Land spoliation and by-passing due to uncoordinated development, including transportation and utility networks.

d. Inadequate recreational land development.

e. Pollution of water.

f. Pollution of air.

2. Land Use

a. Unplanned and uncoordinated expansion of existing urban center.

b. Multi-nodal aspect of the region, not dominated by any single urban configuration.

c. Incompatible land use mix in existing urban areas.

d. Unplanned scattered residential development, lacking community identity and adequate services.

e. Physical decline of inner cities.

f. Lack of region-wide coordinated plans for wastewater disposal.

g. Disorderly and uncoordinated development of utility networks.

h. High proportion of residents without private transportation, lacking adequate mass transit.

i. Inadequacy of land for industrial expansion within cities.

3. <u>Socio-Economic Structure</u>

a. Population growth rates falling below national averages, reflecting an out-migration from the region.

b. Selective dispersal of socio-economic groupings from the central cities to the suburbs, creating a local population decline and concomitant suburban sprawl.

c. Unbalanced distribution of development opportunities in the region.

d. Over-specialization of manufacturing sector in recession-sensitive groups (durable goods).

e. Sustained comparative loss in the manufacturing sector to the larger region and to other areas of the nation.

f. Central cities losing one aspect of their economic base; decentralization of manufacturing, and dispersion to areas removed from local labor force concentration.

g. Racial and economic segregation.

h. Social and economic decline (lower economic growth rate) of the resident population in the inner cities.

NOTES ON SPECIFIC PROBLEMS

Pollution of Water

In an updating of monotonously similar data, the Northern Ohio Urban Systems Research Report (NOUS) indicated that the quality of surface water in the region had reached a critical level and was steadily deteriorating, mostly as a result of industrial waste disposal. They noted that water is one of the area's most available and most widely used resources but that the steady deterioration of quality is a major constraint to meeting future demands. The

pollution of Lake Erie and its tributaries has resulted from the discharge of inadequately treated sanitary and industrial wastes over a long period, with water pollution problems impacting related land as well as water uses. The U.S. Environmental Protection Agency's Cleveland office reports a serious water pollution problem, particularly evidenced in the lower Cuyahoga River and the lakefront; three major steel mills and the City of Cleveland were cited as major polluters and have been on notice for behind-schedule treatment plans. Edwin Odeal, District Engineer for the Three Rivers Watershed District, notes that an intensification of the pollution problem occurs in the Cleveland area because the entire watershed spills out there, with resultant impact on the lakefront. The Great Lakes Basin Commission reports that the sub-basin's greatest problem is related to urbanization, with inadequate planning for the protection and wise use of natural resources, most significantly, the water resource. Although the deteriorated conditions of the region's waters are being seriously addressed and recent construction has made some local improvement in water quality, the lack of a coordinated region-wide system for wastewater management by the multiple municipalities and industry aggravates the water pollution situation and constrains effective quality maintenance.

Pollution of Air

Air pollution is one of the most severe environmental problems facing the region. Air pollution relates to urban congestion, heavy traffic and industrial concentration. The Cleveland-Akron metropolitan area combines all of these factors. Cleveland's Air Pollution Commissioner cites the major problem as a combination of

high particulate levels coupled with high sulfur dioxide emissions, with yearly levels over most of the city being substantially above those considered safe by federal government standards. The costs of air pollution can be measured in damage to human health, vegetation, and materials as well as in relation to visibility reduction and climatic changes.

Land Use Patterns

The land use patterns of the region present a picture of uncoordinated growth. Especially obvious is the scattered development taking place around urban centers, without the services of adequate facilities and isolated from community identity. While older industrial and commercial lands have been straitjacketed by residential development, new industrial parks and shopping centers have arisen in large tracts outside the densely urbanized areas, mainly in close proximity to major highway development. Over the years, the amount of agricultural land has seen a constant shrinkage, while urban land and suburban residential development has increased. Most of this land has been committed to long term use without land use planning and in virtual neglect of other types of coordination. While suburban development in recent years has freed many from the pressures of the central cities, the phenomenon of sprawling suburbanization has created many other problems, not the least of which is the drain on the tax base of the central cities. The pattern of scattered development has resulted in the retention of many smaller governments, intent on preserving their autonomy, but presenting a fragmented and inadequate approach to the provision of public services as well as a barrier to effective regional coordination.

The growth of urbanization with inadequate comprehensive planning for the protection and wise use of natural resources has generated numerous problems in the region, particularly involving water and related land resources. The Great Lakes Basin Commission reports significant inadequacies in the Lake Erie Basin in: land- and water-based recreation, flood protection, water quality protection, and esthetic and cultural opportunities.

Overspecialization of Manufacturing Sector and Recession-Sensitive Industries

The economic base in the region has been largely dependent upon manufacturing. While the percentage of this employment has been overtaken by service industries, the overspecialization of the urbanized centers in certain industry groups, notably durables, is an unfavorable feature since these groups are recession sensitive. In periods of prosperity, the dependence upon durable goods ensures high production and earning levels, resulting in high economic growth rates relative to other areas. Conversely, in periods of recession, production, employment, and earnings fall off much faster than in other regions where economies are more diversified. During the recent recession, unemployment within Cleveland city limits reached 11.8%, twice the 5.9% national average in 1971, with joblessness among the blacks reaching 18.8%. Blame for what ranked as the highest unemployment among the nation's 20 largest cities has been placed on Cleveland's dependence on heavy industry.

Unbalanced Distribution of Development Opportunities

Viewed in the context of the larger northeast Ohio area, it is evident that the economy of the Three Rivers Watershed District is

broadly concentrated along the Cleveland-Akron axis, which is also the main area of urbanization. This area not only has by far the greatest concentration of effective buying income, but also high income values per household as well.

The major transportation networks in the area do not provide equal access and mobility to all parts of the broader region. The Cleveland-Akron axis has experienced the problems of highly concentrated urbanization, while other outside areas that might benefit from development have been unable to do so. There is some indication that the major east-west transverse routes are drawing development, principally the Ohio Turnpike, and Routes 2 and 90, but development is still heavily concentrated within a limited area of the Three Rivers District, particularly in the metropolitan suburbs. Some areas of the broader region have experienced lesser rates of income growth, and in some cases, loss of population.

Central Cities Losing Their Economic Base

A decentralization of manufacturing activities has been taking place in the area, and low income groups residing in the central cities have been unable to follow industrial jobs to new locations. Bureau of Census statistics show substantial losses in manufacturing in Cleveland, as well as wholesale and retail trade, from 1958-1967; the data indicate a loss of 26,500 jobs in the three categories in the city. At the same time, in the areas surrounding the city, the Bureau reports an increase of 90,000 jobs in the three categories. A 1972 Cleveland Plain Dealer study reports a loss of 46 manufacturing companies and 3,808 retail establishments from central Cleveland in recent years. Meanwhile, the city's central residents are

constrained from following the dispersed industrial activity by a public transit system where most service runs within city limits. The report indicates that Cleveland's 840 buses and 117 rapid transit cars cover only 694 route miles when in full service, with routes providing only limited access beyond the city.

Thus, an imbalance in distribution between employment and population has been steadily growing. This is producing a pattern whereby residents from high-income suburbs commute to the city where white-collar jobs are located, while employment opportunities for the lower skilled groups among central city residents are increasingly diverted to the suburbs.

The decentralization of industry has severly diminished the central city tax base and, at the same time, has exported the urban blight to the suburbs and beyond. The selective loss of population and industry from the central cities has depleted their tax resources, and has left an increasing percentage of lower income and less mobile groups who generally require expanded and additional city services. This is the dilemma of the urban core.

In summary, the major problems are:

1. The problem of uncoordinated growth which creates constraining development conditions, exemplified by scattered land use patterns and fragmented government.
2. The problem of congestion and lack of recreation land in the main corridors of urbanization, aggravated by the pollution of air and water.
3. The general decline of the central cities in terms of population and tax base, the suburban areas having deprived them not only of their most affluent residential population, but

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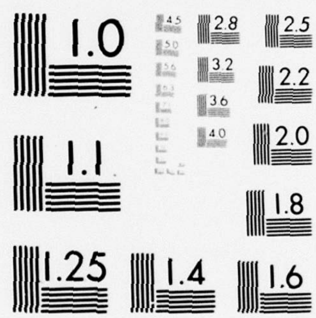

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also, major industrial and commercial establishments. Physical and social deterioration compounds the problem of the central cities.

B. REGIONAL OBJECTIVES

Regional planning objectives for the Three Rivers Watershed area have recently been supplemented in planning documents prepared by the Northeast Ohio Areawide Coordinating Agency (NOACA). NOACA, as a planning group covering the seven counties touched by the watershed, comes the closest to representing a comprehensive view point for the area. Yet, the history of dissension and acrimony among the local government members of the agency makes a consensus most unlikely except for objectives of a most general nature. At this time, many of the goals and objectives are not as clear and precise as they need to be. There is a diversity of outlook among interest groups and institutions regarding many aspects and problems of the region, and indeed, whether a regional concept should exist and how it should be constituted.

The inadequacy of goal-setting mechanisms at the regional level has had several unfortunate consequences. Of primary significance is the absence of any public policy objectives for wastewater management (or other problems generally acknowledged to be regional in nature) that have secured the agreement of the multiple jurisdictions within the study area. Of no less importance is the relative absence of widespread recognition among citizens and interest groups of the specific nature of the wastewater problem and its inseparability from the watershed and the lake.

Nevertheless, even tentative and fragmenting goals will provide a background against which the wastewater managment systems can be evaluated. The material presented has been obtained from a number of government or quasi-government agencies, local jurisdications and sub-regional planning groups, private interest groups, and elements of public expression selected from regional news media. State and interstate expressions have ben obtained from documents of several Ohio departments and the Great Lakes Basin Commission. The following outline classifies these objectives so as to relate them as much as possible to the selected impact categories of ecological, hygienic, social, esthetic, and economic concerns.

1. Ecological (Environmental) Objectives

   a. Natural Resources

      (1) Water

         (a) To cooperate on international agreements on Lake Erie, which call for maintenance of the lake level, non-interference with navigation, and the avoidance of injury to all parties by reason of pollution or by diversion or interference with Lake Erie water.

         (b) To consider resource needs, problems and solutions within the local river basin area, in relation to the Great Lakes system.

         (c) To provide for comprehensive and integrated regional water resource development and management, to assure optimal water supply from both surface and ground sources for domestic, industrial, agricultural, and recreational uses.

(d) To identify reservoir sites and aquifers for protection and acquisition before loss or damage from competing land uses.

(e) To protect and preserve property endangered by shore erosion along Lake Erie and inland waters.

(f) To provide a flood control program incorporating flood plain zoning.

(g) To establish water quality standards for Lake Erie and streams tributary to the lake.

(h) To inventory and project pollutional loads from domestic and industrial sources, and provide the treatment and regional systems required to meet water quality standards.

(i) To identify other pollution, such as from erosion or acid mine drainage, and recommend specific projects or research directed at its prevention.

(j) To establish stream monitoring as a surveillance tool in enforcing water quality standards.

(k) To assure adequate waterways for commercial navigation.

(l) To assure ample water-based recreational opportunity through lake and river valley acquisitions and development, and the attainment of clean streams and beaches.

(m) To identify specific projects in need of research in all areas of regional water management.

(2) Air

(a) To adopt uniform air quality standards for the region.

(b) To coordinate federal, state, and local efforts for prevention of air pollution.

(c) To seek cooperation between private and public sectors to implement air quality standards.

(3) Energy - Minerals

(a) To encourage the efficient use and conservation of the mineral and energy resources of the region.

(b) To provide accessibility to natural and mineral resources vital to the area.

(c) To avoid disruption or destruction of land by inefficient or short-sighted practices that make it unavailable for subsequent uses such as industrial development or extraction of resources.

b. <u>Land Use</u>

(1) Development

(a) To recognize in planning, that the natural resource base is limited and that it is subject to misuse and serious environmental damage.

(b) To coordinate land use policy with areawide planning in order to permit an efficient provision of urban services, and to eliminate urban sprawl.

(c) To direct the development of public facilities and services such as education, water supply, waste treatment and disposal systems in order to provide acceptable levels of service with the greatest possible efficiency.

(d) To encourage development and redevelopment in areas where existing facilities and services are adequate.

(e) To encourage integration of rights-of-way for different facilities--highway, rail, power and pipelines.

(f) To encourage development in areas to which existing facilities and services can be economically and efficiently extended; to respond to change in demand and growth potential.

(g) To promote redevelopment and rehabilitation of deteriorated areas with emphasis on the needs of low income and minority groups affected; to remove facilities that do not provide adequate living conditions and threaten adjoining residential areas.

(h) To promote desired physical development by integrating transportation planning into area development, and providing appropriate accessibility to various land uses.

(i) To formulate a transportation system incorporating all modes as part of a general development plan for the region.

(2) Open Space

(a) To recognize open space as an integral part of the urban land use pattern rather than as undeveloped real estate.

(b) To provide definition of urban form, and relief from high density urban development and activity by functional and esthetic open space.

(c) To conserve and protect natural features of the land to the fullest extent during development, and to coordinate open space planning with other planning to effectively use natural land characteristics.

(d) To avoid encroachment on sites or areas of historic cultural, scientific, or esthetic significance; to preserve areas of outstanding beauty by purchase, easement, or other suitable tools.

(e) To provide easily accessible sites to satisfy the outdoor recreational needs of the regional population.

(f) To preserve a balance between public and private recreational facilities.

2. Social Objectives

a. Freedom of Choice

(1) To provide maximum opportunity for individual initiative and freedom of choice.

(2) To enable free choice of housing location and type for the individual.

(3) To provide choice of travel modes between places of residence and employment, especially for mass transit dependent population.

(4) To maintain and develop a quantity and variety of job opportunities in accessible sites to allow free choice of employment to the individual.

b. Social Participation

(1) To increase the opportunity for individual involvement and constructive participation in the activity of the community.

(2) To involve minority and low-income groups significantly in the decision-making process.

(3) To encourage constructive social relationships among the people of the area, promote ethnic and racial harmony, and create a sense of community.

(4) To recognize the variety of religious and cultural heritages extant in the area, and provide for the spiritual development of the individual.

(5) To encourage a sense of dignity, self respect, and personal responsibility in individuals of the area.

(6) To encourage individual self-development through education and training; to encourage an appreciation of esthetic values.

c. Neighborhood Development

(1) To foster maintenance and development of a quantity and variety of housing types to satisfy desired life styles and financial capacities of area population.

(2) To maintain safe and healthful living conditions in residential areas by provision of necessary public facilities and services.

(3) To provide adequate housing for low income families and to maintain housing units which provide desirable living accommodations at low cost.

(4) To preserve and create residential areas which foster opportunities for constructive social relationships as well as provide for privacy.

(5) To maintain established neighborhoods and the social relationships that depend on the stability of certain

types of housing and physical facilities.

d. Regional Coordination

(1) To encourage orderly and balanced growth and optimal development.

(2) To identify area-wide needs and opportunities and yet reflect individual community characteristics.

(3) To coordinate all levels of government to realize area-wide as well as local objectives and plans.

(4) To provide a forum to share ideas and information.

(5) To provide alternatives for consideration in the resolution of problems.

3. Economic Objectives

a. Economic Growth

(1) To maintain and improve the area's competitive economic condition.

(2) To create a climate to attract service industries, light manufacturing, research and development, and administrative headquarters to complement the concentrations of heavy industry.

b. Industrial Development

(1) To promote the preservation of prime industrial areas to provide for the future orderly growth and expansion of the industrial-commerical base.

(2) To foster industrial and commercial development at planned locations by providing superior transport service, externally to major markets and resource areas, and internally between related industrial and natural resource areas.

(3) To provide the best possible relationship to locally available resources such as minerals, water, and soil deposits.

(4) To maintain established or planned trade and service areas of regional and community business centers.

(5) To increase accessibility to and within major business districts to permit efficient movement of people, goods, and materials.

c. Employment Opportunity

(1) To maintain and develop a quantity and variety of job opportunities which will allow employment of all persons in the region who possess employable skills.

(2) To maximize the use of cultural, educational, natural, and economic resources of the area to broaden the choices and enrich the life style of regional employees in order to encourage through them, the retention, attraction, and expansion of industry.

4. <u>Esthetic Objectives</u>

a. To identify and preserve vestiges of vanishing wilderness, scenic, and historic areas adjacent to rivers and lakes.

b. To eliminate visual pollution such as stream and bank litter, local dumps, and excessive suspended solids input due to human activities.

c. To preserve and provide access to areas of outstanding beauty by purchase, easement, or other means.

d. To retain the normal topography and drainage, and preserve natural vegetation in any developmental activity.

e. To provide for acquisition and preservation of wildlife habitats, including game areas, wetlands, and preserves; to provide opportunity for fishing and hunting.

f. To foster urbanization patterns in which significant areas and features of the natural environment are preserved; to provide definition of urban form by open spaces.

5. Hygienic Objectives

a. To develop an orientation to the prevention of disease, and to the early detection and treatment of chronic disease.

b. To increase the potential for delivery of health services through increasing the capacity of current facilities as well as the expansion of resources.

c. To influence the present arrangements for health services in a manner that will permit the best in modern medical care for heart disease, cancer, stroke, and related diseases to be available to all.

d. To overcome the deficit of health among the poor by providing for immediate health service needs, including improved access.

e. To promote more equitable distribution of traditional and innovative health services in accordance with geographic, racial, and low income needs.

f. To improve the quality, marketing, and effectiveness of health education; to develop a central source for health information.

g. To resolve the problem of the fragmentation of health services and to improve community emergency care.

h. To improve the quality of medical services through professional and public education.

i. To coordinate a regional approach to the management of wastewater and water resources.

j. To encourage the development of a total solid waste management program for the region.

C. SUBREGIONAL OBJECTIVES

The regional objectives provide a general framework for area-wide development. However, the region is the sum of a number of disparate parts, not all of which agree in their respective development goals. Any analysis of regional potential should recognize the subregional differentials, particularly those that reflect on development requiring water and waste management. The following will indicate a limited aspect of the goals of the several planning jurisdictions of Cuyahoga, Geauga, and Lake Counties, and the Tri-County area of Medina, Portage, and Summit Counties.

Although Lorain County has a small portion of two townships within the watershed, the development of the county is anticipated without major relationship to the Cleveland area. The cities of Lorain and Elyria are large enough to have their own identity and form a core around which future development probably will take place. Both the topography and the river valleys favor a north-south city orientation rather than an east-west orientation toward Cleveland. This, and the extended travel time have promoted commercial development in areas associated with central business districts. Lorain County, at least for the near future, is expected to develop apart from the Cleveland-Akron concentration.

For the other counties in the basin, the association with the metropolitan axis will be a predominating influence. Lake County will exhibit an essentially linear pattern of development, extending from the Cleveland area eastward along the lake basin. Geauga County presents a defensive pattern, limiting development to present growth centers and areas closest to Cuyahoga County and hoping to preserve large areas of agricultural and open space. Both Cuyahoga and Summit Counties are concerned with the maintenance and strengthening of existing urban centers with Medina and Portage Counties anticipating growth, but as satellite communities. Some specific patterns are indicated as follows:

1. Cuyahoga County

Drastically revised population projections for Cuyahoga County indicate a need for redevelopment and revitalization in concert with a greatly reduced growth potential. Although the central city will continue to decline in population and the suburbs will increase the overall county population will show little overall increase. The objectives for specific development will include:

a. Residential

(1) The number of single family homes built will continue to decline due to high unit construction cost and lack of vacant land. Multi-family construction will comprise most of the county's new housing.

(2) Development will occur toward the borders of the county where the most vacant land and readily developable acreage exist.

(3) Population will approach 8,000 per square mile in Cleveland and older central communities by 1990, as few as 500 per square mile in far eastern suburbs.

b. Business and Industry

(1) Manufacturing will experience little overall growth due to plant obsolescence and adverse environmental conditions in older industrial areas.

(2) Major occupational groups will include trade, finance, services, and government employment.

(3) Strip and scattered commercial development will decline and will need redevelopment to other uses.

(4) Additional regional centers will develop, related to expanded industrial development.

(5) Office space will increase by 3.5 million square feet for expansion replacement purposes.

c. Open Space and Recreation

(1) There will be a need for conservation of the little land available, with designation of flood plains, marshes, and steeply sloping lands for open space preservation.

(2) The growing recreation needs of the metropolis are acknowledged.

d. Sewer and Water

(1) The highest priority is directed toward the alleviation of sewer and water planning problems.

2. Geauga County

Geauga County's plan is basically a statement to reinforce existing trends and conditions. Present urban areas will be expanded to accommodate a large part of the expected growth. The county aims to maintain its rural/low density residential character as much as possible. Objectives for specific development components include:

a. Residential

(1) High density development to be concentrated in or adjacent to existing urban centers, closely related to major transportation and utility systems.

(2) Medium density development to be provided in areas which can be serviced by public water and sewer systems.

b. Agricultural

(1) Preserve the county's prime agricultural land.

c. Business and Industry

(1) Closely related to adequate transportation, water, and sewage facilities.

(2) Compact development: Business to be located no more than one mile from an existing area.

(3) Industry to be buffered from surroundings.

d. Open Space and Recreation

(1) Preservation of major valleys.

(2) Triple the land committed to hunting preserves.

(3) Develop two state parks and several county parks; extensive development of scenic routes for hiking, horseback riding, etc.

(4) Restrict urban development in areas with severe soil limitations.

(5) One-third of county area to be retained for open space and recreation.

e. Sewer and Water

(1) Develop the West Branch of the Cuyahoga River for eastern townships.

(2) Western area to obtain water supply from Cleveland.

(3) Expand existing municipal treatment plants.

(4) One new reservoir.

(5) System to serve the entire developable area of Geauga County (ranging from interceptor system to individual septic tank systems).

3. Lake County

Current planning objectives are not available from Lake County but it is understood that updated planning elements are in preparation. Present development generally follows the zoning pattern, with a strong tendency toward a linear arrangement influenced by Routes 2 and 90. There is no compact core, but rather a broad band lying in the lake plain along which the highest residential and industrial densities are arranged. The pattern is due to a combination of topography, location in relation to Cleveland, and the physical size and shape of the county. Median densities are located between this band and the lakefront, with lower densities in the southern edges of the county.

4. Tri-County Area: Medina, Portage and Summit Counties

Tri-County planning objectives must be somewhat ambivalent, with concern for the maintenance and stregthening of existing urban centers and recognition that higher rates of growth must be anticipated in new centers in Medina and Portage Counties. The assumption of a continuing growth pattern is tempered by recent population studies indicating a rate considerably decreased from previous estimates. Nevertheless, their published policies reflect an anticipated high rate of growth.

a. Residential

(1) Accelerate housing construction, including moderate and low income, public housing.

(2) Promote new ideas in housing and site design, including planned unit development, cluster subdivisions, and multiple dwelling innovations; promote smaller lot sizes for savings in cost of utilities.

(3) Assure full access to utilities, services, and employment centers, and prevent noncompatible uses.

(4) Prevent construction in areas lacking services and facilities, or in areas of poor soil conditions, flood plains.

(5) Accelerate slum clearance and use mechanisms to promote maintenance and prevent blight.

b. Business and Industry

(1) Promote the expansion of existing industries and the attraction of new industry by a variety of governmental actions.

(2) Provide industrial land, and promote industrial and research parks--by zoning, outright purchase, and protection from competition and encroachment.

(3) Provide industrial areas with all essential facilities, parking, loading, landscaping.

(4) Promote commercial development of an integrated and compact nature, related to market areas and appropriately spaced.

(5) Ensure use of older commercial areas through redevelopment and transportation accessibility.

c. Open Space

(1) Use a variety of zoning and subdivision regulations to preserve usable open space and recreation lands.

(2) Public fiscal policy, and where necessary, public acquisition should be used to encourage owners of open land to maintain the natural character.

(3) Outdoor recreation plans to be included as part of landscape plans, assignment of priority for development.

(4) Develop a program of public education for appreciation of the value of open space and recreation.

d. Sewer and Water

(1) Provide for planning and development of water resources on a watershed basis, supported by watershed districts and regional water authorities.

(2) Protect water storage sites; promote the development of agricultural, conservation, and recreational uses upstream, and urban development downstream; restrict land use in flood plain areas.

(3) Provide central water supply systems to all urban and suburban land development; prevent the overuse of ground water supply.

(4) Promote water reuse and the idea of diversion of Lake Erie water to the Cuyahoga.

(5) Provide sanitary sewer systems to all urban and suburban development; provide sewer systems by drainage basins rather than municipal boundary.

(6) Encourage regional sewer districts and eventual unification of water and sewer management, including storm water.

(7) Industrial plants with significant pollution problems should provide on-site pretreatment.

D. SUMMARY AND RELATIONSHIP TO EVALUATION

From this overall review of regional objectives a subset can be derived that will be most directly impacted upon by wastewater management systems. All such planning within the region must take these objectives into account. In order of priority the objectives are:

(1) The alleviation of sewer and water planning problems throughout the region. The ramifications of this include the thirteen objectives listed above under "Water" as a "Natural Resource" and the water specific objectives provided for each of the subregional areas.

(2) The satisfaction of the growing recreation needs of the metropolitan areas. This includes recognition of inadequate recreational land development and, ideally, pro-

vision for outdoor recreation as part of any large scale wastewater management. This would help to meet the demand for easily accessible sites to satisfy the outdoor recreational needs of the regional population.

(3) The elimination of present patterns of unplanned, scattered residential development, lacking community identity and adequate services. With this goes the conservation and protection of valuable natural features of the land and the coordination of wastewater management planning with open space planning. This also includes the preservation of scenic, historic, and relative wilderness areas adjacent to rivers and lakes.

(4) The achievement of the best possible relationship to regionally available resources such as minerals, water, soil deposits, ecologically protected land, and reclamation sites.

Evaluation procedures are intimately related to goals and objectives. A true measure, by which courses of action should be evaluated, is the degree to which they achieve goals. Inadequacies in evaluation will constrain effective planning. By the same token, an overriding limitation on effective planning for water resources generally has been the lack of definition of clear social, economic, and environmental goals.

The extended recital of the planning objectives of the region indicates that this limitation has only partially been overcome. The objectives cited relate to the major problems of uncoordinated

growth, the decline of the cities, and the increasing concentration and congestion that places a growing stress on our inventory of natural resources. The direct relationship of these objectives to the problem of wastewater management is somewhat obscure. With certain exceptions, the objectives are imprecise and non-specific.

There are reasons for this situation. Planners generally have a responsibility for leadership in the definition of goals that relate to the needs and aspirations of the people affected. However, goals that are established prior to a knowledge of the consequences of their attainment, can realistically only be general guidelines. Though initially, goals and objectives must be hypothesized, they should be finalized only when costs and benefits and consequences are fully understood.

Equally constraining to specificity is the lack of an effective governmental vehicle for marshalling the whole spectrum of public planning for achieving goals. For instance, the development of river basin and urban planning have followed separate paths. Techniques, criteria and clientele have evolved differentially, and a successful integration between urban needs and river basin planning remains a major problem. There is a larger context of problems that includes urban concentration, social and economic maladjustment, and environmental degradation, within which the place of water resources planning must be established. Only in such a context can a wastewater project be developed and managed as an environmental tool, and not as an end in itself.

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V. REGIONAL CHARACTERISTICS

A. INTRODUCTION

1. Historical Development

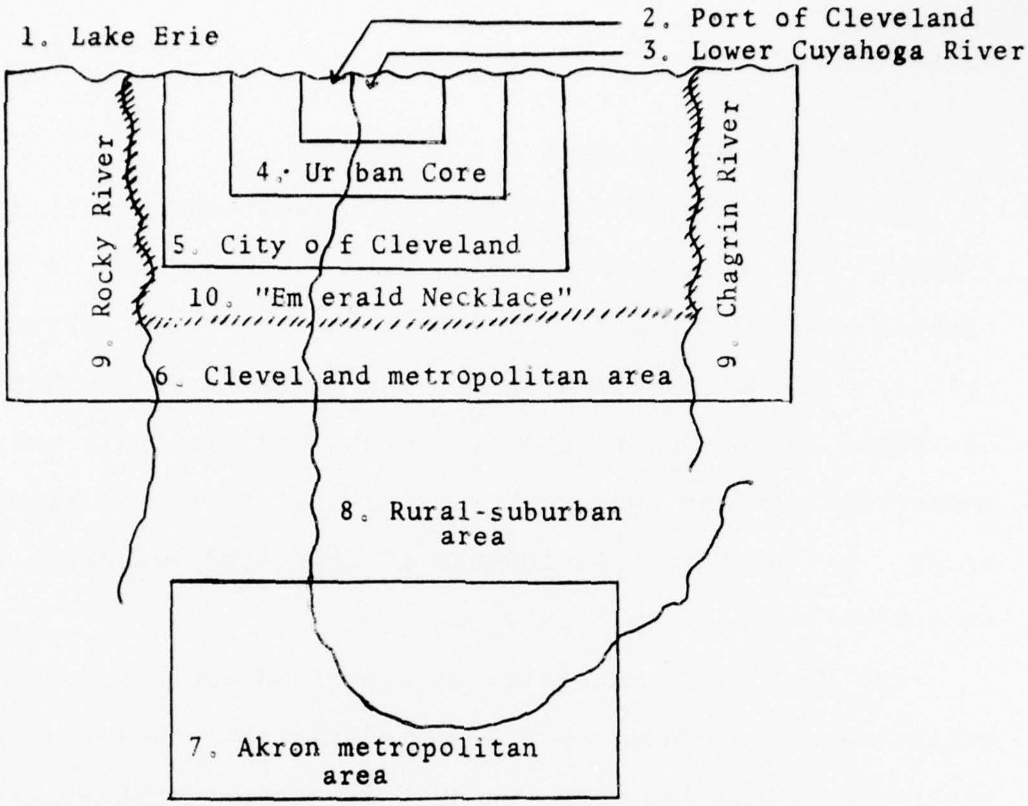
The Three Rivers Watershed District is characterized by a T-shaped pattern of urbanization with the cross arm of the T extending along the Lake Erie shore and the trunk corresponding with the Cleveland-Akron axis. The District is dominated by the Cleveland and Akron metropolitan areas and is highly urbanized, industrialized and developed. It has all of the problems of such areas. A schematic relationship of Cleveland and Akron to water resources is shown in Figure 1.

The historical evolution of Cleveland and Akron as major urban centers was influenced by a score of factors. Water supply and water transportation were the most important considerations in the original site selections, with the subsequent Canal Era (1825-1845) spurring the growth of the settlements as trade and manufacturing centers.

Water transportation played a very important role in the growth of the area. The settlement of Cleveland began with the landing of a surveying party for the Connecticut Land Company at the mouth of the Cuyahoga River on July 22, 1796. The opening of the Erie Canal in 1825 connected Cleveland and all the Lake towns with the State of New York. Two years later Cleveland and Akron were linked with the interior of the State of Ohio as a result of the completion of the Ohio Canal between the Ohio River and the village of Cleveland.

In the second half of the nineteenth century, Cleveland, being a water transportation center, also became an important center of the

Figure 1. Schematic map of the Cleveland metropolitan area and its water resources.



1. Lake Erie
2. The Port of Cleveland, the major interface between the economic community of Cleveland and its major water resource
3. The lower Cuyahoga River, the major industrial water-related sector
4. The Cleveland urban core
5. The City of Cleveland
6. The Cleveland metropolitan area, major suburbs
7. The Akron metropolitan area, the major upstream development of the Cuyahoga River watershed
8. The rural-suburban area outside the region's two major metropolitan centers
9. The inland waterways and valleys, Rocky River, Cuyahoga River, Chagrin River
10. The metropolitan park system, major valley land user, known as the "Emerald Necklace."

From: Whitman, Davis and Goldstone, "Measuring Impacts of Urban Water Development," Water Resources Bulletin, Vol. 7: 4 August 1971.

Industrial Revolution. The iron ore of the Marquette range in upper Michigan and the coal of eastern Ohio were brought to the city for smelting. The demands of the Civil War accelerated the development of the iron and steel industry. By 1910, according to the Census of Manufacturing, Cleveland had become the sixth industrial center in the United States. At the same time Cleveland was also the fifth most populous center in the entire nation.

Cleveland emerged as a major railroad transportation center in the 1850's. The confluence of Pennsylvania coal and Lake Superior iron ores produced an industrial city during the second half of the 19th century. The period since 1910 has been characterized by the rising importance of the suburbs in Cuyahoga County, with the subsequent outward shift of retail as well as wholesale trade. The increasing mobility of people, aided by the automobile, accelerated the outward movement of families with higher incomes. The advent of the trucking industry and the developemnt of industrial parks made it possible for several industries to move out of the city to where better land conditions existed. The concurrent decline in residential population, total income, retail, wholesale and industrial activity is resulting in a lower tax base for the City of Cleveland. At the same time there is an increasing demand for municipal services, much of which is generated by changing population characteristics.

Akron's continuation of growth, after the Canal Era, was ensured by good railroad connections, but it was the relocation of Goodrich's rubber factory from the east to Akron which started a new era for the city. With the coming of the automobile era, the rubber industry grew rapidly. Akron became essentially a one-industry town,

with its population more than doubling in the decade of 1910-1920.

Since World War II, the rubber industry has been building many of its new plants in other locations in the nation. At the same time, low cost land and the desire to escape from the central city have created a demand for residential development. Commercial uses have been moving outward in response to residential movement, and this coupled with the job erosion and the cyclical nature of the rubber industry have formed a considerable part of the Akron urban plight.

2. Physiography

The Three Rivers Watershed comprises three river systems: the Rocky, the Cuyahoga and the Chagrin. The rivers flow generally northward into Lake Erie from the divide between the St. Lawrence and the Mississippi River drainage. The rivers drop in elevation from 1250-1300 feet in the headwaters, to the Lake Erie elevation of 572 feet. The study area extends from Eastlake (on Lake Erie) southeast to Chardon, southward to Ravenna and Hartville, northwest to Akron, then westward to Medina and north to Bay Village and Lake Erie, the total drainage area is 1507 square miles.

A relatively distinct escarpment divides the basin between the upland plateau and the lake plain. Areas of the lacustrine plain which border the lake are quite narrow and in many places absent where wave action or littoral current have created steep bluffs in the lakeshore. In the plain, the main streams are deeply entrenched and the valley floors often narrow as are the Rocky and Chagrin Rivers. The lower course of the Cuyahoga is flat floored and wider. Pleistocene lakes once occupied these lower areas, and the silt

laid down is exposed at many places along the valley walls. Erosion of these deposits contributes to the sediment load of the rivers.

The topography of the upland area is glacial in origin and generally consists of rolling hills heavily dissected with steep stream and river valleys. The terrain is variable; at some locations streams are of moderate slope and meander through wider valleys while in other areas channel gradients are steep with flow through deep valleys. The upper reaches of the rivers are largely wooded and the area has many small lakes and ponds and swampy areas. The upland area was developed as a result of Pleistocene glaciation and the surficial material is unconsolidated and highly variable. For the most part, soils formed on this glacial material have silt and clay loam textures with slow internal drainage. The coarser sand and gravels of flood plains and glacial outwash do occur locally.

The Rocky River Basin is the westerly of the three rivers and drains an area of 294 square miles in Medina, Summit, Lorain, and Cuyahoga Counties. The river has two main courses. The West Branch and its major tributary, the North Branch, drain the north central section of Medina and portions of Lorain County. The East Branch drains the north-east section of Medina and portions of Cuyahoga County. The two branches join at North Olmsted, flowing north to Lake Erie in a single, narrow, steep-walled valley. Most of the East Branch and the main stem flows through the Rocky River Reservation of Cleveland Metropolitan Park System. Many small streams are tributary to these main branches, including Mallet and Plum Creeks to the West Branch and Baldwin and Abrams Creek to the East Branch.

The Chagrin River Basin, located in the northeast of the larger basin area, drains an area of 267 square miles in Cuyahoga, Geauga, Lake and Portage Counties. The main river rises south of the Village of Chardon and flows southwesterly to Chagrin Falls where it joins the Aurora Branch coming from the south. From here, the river flows north through the easterly suburbs of Cleveland, joining the East Branch at Willoughby and then discharging to Lake Erie at Eastlake. Much of the upland watershed is generally rolling, wooded land. The lower twenty-five miles of the channel is deeply entrenched on bed rock until it emerges on the flood plain below Willoughby.

The Cuyahoga River Basin drains an area of 813 square miles. Beginning east of Chardon, only 16 miles from Lake Erie, the river flows in a southerly direction to Lake Rockwell, northwest of Ravenna. This impoundment, used for Akron water supply, severly limits the flow of the river and in extremely dry weather permits no flow except for the washwater from the Akron filters. The river at that time may consist only of leakages and the drainage from small tributaries. Below Lake Rockwell, the river flows southwesterly through Kent to Akron where it begins a northerly course through the greater Cleveland area to Lake Erie. Principal tributaries and the area they drain include the Little Cuyahoga River (68.9 sq. mi.), Breakneck Creek (79.0 sq. mi.), Tinkers Creek (96.4 sq. mi.), and Big Creek (38.6 sq. mil). The last six miles of the Cuyahoga constitute a navigation channel with special problems that are inherent in its use and maintenance.

In addition to the major rivers, there are several smaller stream basins directly tributary to Lake Erie. In order of their

occurence from east to west, they include Euclid, Green and Nine Mile Creeks, Shaw Brook, Dugway Creek and Doan Brook. West of the Rocky River are Sperry, Cahoon and Porter Creeks. The combined drainage area of these minor creeks flowing directly to Lake Erie is approximately 133 square miles.

3. Climate

The general climate of the Three Rivers area is moderate. The average annual precipitation is about 37 inches, fairly evenly distributed throughout the year, but somewhat heavier in summer than in winter. About one-third of the precipitation appear as run-off in the rivers, the rest being absorbed in the soil, in other surface waters, in vegetation or lost through evaporation. January through April are months of typically heavy run-off while summer and early fall are periods of low run-off. The variation is significant in the consideration of water management practices in the area. Close proximity to Lake Erie tends to moderate extremes in temperature. Monthly mean temperatures range from 18 degrees to 71 degrees Fahrenheit with an average of 47 degrees F. Mean temperatures above freezing occur during the period from March through November and the growing season averages 182 days. Monthly climatic data from the Cleveland Weather Bureau are presented in Table 3. Average temperatures and precipitation for all counties are presented in Table 4.

4. Land Use

The Northeast Ohio area which includes the Three Rivers Basin is characterized by considerable attractive scenery, the preservation of which should be a major concern. The area includes a heavily

TABLE 3. Monthly Climatic Data for Cleveland, Ohio

	Length of Record (in years)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Normal Monthly Temp.	30	27.6	27.6	35.4	46.6	57.5	67.2	71.5	69.9	63.4	52.8	40.4	29.9	49.2
Normal Daily Max. Temp.	30	34.8	35.6	44.1	57.5	68.7	78.1	82.8	81.2	74.5	63.6	49.0	36.9	58.9
Normal Daily Min. Temp.	30	20.3	19.6	26.7	35.7	46.3	56.2	60.2	58.5	52.3	42.0	31.8	22.9	39.4
High Temp. Extreme	36	73	72	83	88	95	102	107	102	101	90	82	69	107
Low Temp. Extreme	36	-19	-15	-5	10	26	39	43	41	34	23	4	-9	-19
Normal Mo. & Annual Precip.	30	2.67	2.33	3.13	3.41	3.52	3.43	3.31	3.28	2.90	2.42	2.61	2.34	35.35
Avg. No. Days Precip. .01+	25	16	14	16	15	13	11	10	9	9	10	14	16	153
Avg. Total Snow & Sleet	25	10.4	10.5	10.5	2.4	Trace	--	--	--	Trace	0.7	5.4	11.0	50.9
Avg. Hrly. Wind Speed	25	12.5	12.4	12.8	12.2	10.6	9.5	8.9	8.5	9.3	10.2	12.4	12.5	11.0
Normal Degree Days 65° Base	30	1,159	1,047	918	552	260	66	9	25	105	384	738	1,088	6,351
Avg. % Possible Sunshine	25	30	35	44	51	60	67	68	65	61	56	33	28	52

Source: U.S. Dept. of Commerce, Environmental Science Services Administration.

TABLE 4. Average Temperatures, Precipitation & Growing Season Days, 1970, for Counties in the Three River Watershed Area.

County	Average Temperature													Precip. Annual Inches	Growing Season Days
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual		
Cuyahoga	18.9	27.2	33.8	50.2	62.7	69.8	71.9	69.9	66.0	54.4	41.6	32.2	49.9	33.66	185
Geauga	15.6	22.7	29.3	46.4	59.0		69.0	68.5	65.2	53.7	40.5	30.6	*	40.49	185
Lake	21.8	28.6	32.4	48.8	62.1	69.5	72.9	73.3	68.6	57.2	57.2	44.5	35.1	32.82	193
Lorain	19.2	27.4	33.8	50.4	63.6	69.3	72.8	72.5	68.4	55.8	42.8	33.5	50.8	33.78	185
Medina	18.3	26.3	33.2	49.8	62.6	67.9	71.2	69.7	66.9	55.0	41.4	31.7	49.5	35.53	163
Portage	17.7	23.3	31.8	48.5	61.7	65.3	70.2	69.3			41.8	32.0	*	43.56	180
Summit	19.6	26.5	33.4	50.1	62.1	68.8	71.9	71.5	67.6	56.3	42.7	32.0	50.2	38.23	185
Total Watershed Avg.	18.7	26.0	32.5	49.2	61.9	68.4	71.4	70.5	67.1	55.4	44.0	33.8	46.7*	36.9	182

*Annual averages are based on months where data was available.

Source: Environmental Science Services Administration.

dissected plateau with deeply incised river valleys. Much of the length of the valleys of the Three Rivers and their tributaries are in a youthful stage of development being narrow and steep sided. The upland area varies from level to rolling terrain, with considerable natural vegetation. Soil types in general are moderately favorable for agriculture, though there are extensive areas not available because of poor drainage or steep slopes.

The lower courses of the Rocky and Chagrin Rivers are in narrow and precipitous valleys, but the lower course of the Cuyahoga is flat floored and wider and constitutes an area known as the flats. The principal heavy industrial concentration of the region has developed in this area. The industries in this area have physical plants which are older than new single-floor structures which are being constructed in outlying suburban areas. The lower six miles of the Cuyahoga River are served by a federal navigation project used by medium sized lake vessels. For a number of miles the Cuyahoga is in a mature valley spanned by several high-level highway bridges.

In general, land uses in the region vary from completly urban to completely rural, but inter-urban coalescence is proceeding rapidly. The rate of absorption of land by urban uses substantially exceeds the rate of population growth. The result is a generally lowering of population density in the inner cities. At the same time suburban and ex-urban development is occuring at substantially lower densities than those of earlier suburban developments. For example, between 1960 and 1970 the population of the central city of Cleveland declined from 876,000 to 750,000 while the population

of the larger Standard Metropolitan Statistical Area (SMSA) increased from 1.0 million to 1.3 million. Between 1960 and 1970 the population of Akron's central city declined from 290,000 to 275,000 while the population of the Akron SMSA increased from 315,000 to 403,800.

The area's urbanization takes the form of a multi-nucleated conurbation. The principal nuclei are downtown Cleveland, located on the shores of Lake Erie, and Akron located on the divide at the southern edge of the Cuyahoga basin. Both of the central nuclei have been declining in relative and in absolute importance in recent decades. Yet, they still constitute the principal nodes within the region. Extensive highway and railroad networks facilitate the movement of people and goods throughout the larger region and unify the economic base of the area. External connections by railroad and by highway are reinforced by major port and airport facilities. A principal port facility is located on the shore of Lake Erie, adjacent to downtown Cleveland. Here ocean-going ships are handled. Port facilities are also located on the Lake Shore west of the Cuyahoga River mouth as well as in the lower six miles of the River where inter-lake and intra-lake bulk cargoes are handled. The principal airport connections are through Cleveland-Hopkins Airport which is lcoated on the upland adjacent to the Rocky River valley. This airport is classified as a "large hub" and ranks 16th in the United States in volume of air passenger traffic. It is also provided with extensive air cargo facilities. In addition, the region has a substantial number of general aviation airports.

Rural land-uses consist principally of general farming and

dairying. In places these activities are supplemented by specialized production which includes fruit and vegetables. The extent of agricultural use has been declining with rapid urbanization of countryside.

a. Agricultural Characteristics

Rural land use in the Three Rivers Basin consists principally of general dairying and farming. In some places this activity is supplemented by specialized production which includes fruits and vegetables. Upland soil types in general are moderately favorable for agriculture, though there are extensive areas that are unavail able because of poor drainage or steep slopes. The climatic conditions relating to agricultural land use are given in Table 5, while Table 6 provides selected agricultural characteristics for the Basin counties.

The extent of agricultural land use has been declining with the rapid urbanization of the countryside, and a general trend is indicated toward a smaller number of farms with larger land holdings The data on land in farms of the Northeast Ohio counties within the Three Rivers Basin indicating changes during the period 1954 through 1969 substantiates this trend. (Table 6). The proportion of county area in rural use during the period 1954-1969 has dropped from 35% to 11% in Summit County, 12% to 4% in Cuyahoga County, 63% to 39% in Portage County and 60% to 28% in Geauga County This

TABLE 5 Precipitation and Growing Season by County, 1970

County and Station	Inches/Annual Precipitation	Growing Season in Days
Ashtabula, Ashtabula	35.57	193
Cuyahoga, Cleveland	33.66	185
Geauga, Chardon	40.49	185
Lake, Painesville	32.82	193
Medina, Chippewa Lake	35.53	163
Portage, Hiram	43.56	180*
Summit, Akron-Canton W.S.	38.23	185
Lorain, Elyria	33.78	185

*1969 figures

Source: Ohio Almanac, 5th Edition, 1972.

TABLE 6

Selected Agricultural Characteristics: Counties in 3-River Watershed Area

	Ashtabula	Cuyahoga	Geauga	Lake	Medina	Portage	Summit	State Total
Land in farms (acres)	191,993	10,379	69,527	21,159	144,178	124,315	27,592	17,111,459
% of county		3.5%	26.6%	14%	53%	38%	10%	
Average size of farm	127.9	38.1	120.2	69.1	111.9	120.6	87.5	153.6
Avg. value per acre (land & buildings)	$286	$2,450	$465	$1,157	$518	$474	$1,101	$399
Farm land uses (acres)								
Total cropland	114,396	5,730	38,610	14,169	102,624	76,490	18,380	12,447,089
Harvested cropland	66,086	4,074	22,721	8,938	64,486	50,333	12,168	8,515,275
Woodland including woodland pasture	46,665	1,630	18,575	2,966	21,247	20,051	4,389	2,179,233
Irrigated land	387	323	37	1,287	454	1,118	266	22,087
Farm production value								
Market value of all agricultural products sold	$13,467,225	$9,017,994	$4,921,057	$10,498,948	$11,363,033	$10,360,208	$9,696,248	$1,246,071,615
Value of crops incl. nursery products & hay sold	$3,740,999	$8,607,092	$722,737	$9,959,266	$2,555,140	$3,178,098	$8,440,665	$489,107,809
Value of livestock, poultry & their products sold	$9,633,397	$402,167	$4,020,288	$529,369	$8,766,700	$7,129,237	$1,243,277	$752,980,903
Livestock & Poultry								
Cattle & calves (total)	28,583	771	9,322	1,141	21,768	17,577	3,494	1,910,129
Sales	$14,280	$804	$4,590	$700	$10,556	$9,092	$1,363	$1,161,087
Milk cows on place	13,255	163	4,754	175	9,362	6,607	1,061	424,237
Hogs & pigs	5,345	150	1,748	193	7,881	4,162	566	2,478,758
Sales	$6,952	228	$5,050	$604	$12,792	$6,910	$686	$4,103,601
Sheep & Lambs	2,284	351	1,069	336	3,591	2,409	949	747,087
Sales	$1,510	$222	$780	$320	$2,741	$1,555	$494	$610,890
Chickens 3 mos or more	67,178	13,362	113,655	60,802	134,177	129,805	54,381	11,878,069
Broilers & other meat-type chickens less than 3 mos. old (sales)	50	700			1,370			8,871,024

TABLE 6 (cont.) Selected Agricultural Characteristics: Counties in 3-River Watershed Area

	Ashtabula	Cuyahoga	Geauga	Lake	Medina	Portage	Summit	State Total
Crops harvested (acres)								
Field corn for all purposes	16,498	574	5,081	1,039	19,975	15,266	2,611	2,937,806
Wheat for grain	3,349	257	1,088	482	6,186	4,410	2,334	1,003,915
Soybeans	1,418	475	57	78	5,966	843	652	2,387,587
Hay (excluding sorghum hay)	31,181	886	11,786	1,669	24,537	18,493	4,774	1,383,727
Alfalfa & alfalfa mixtures for hay or dehydrating	2,157	122	1,413	382	7,950	2,881	1,195	360,666
Irish potatoes & sweet potatoes	208	-	31	20	46	1,644	135	14,359
Vegetables, sweet corn or melons for sale	358	890	170	102	171	1,301	683	66,744
Berries	30	19	11	54	68	66	9	2,182
Land in orchards	2,700	282	306	924	371	353	324	31,557
Greenhouse products under glass or other protection (sq. ft.)	1,612,275	7,960,945	77.657	469,156	782,152	586,652	641,224	36,260,795
(acres)		182	2	11	18	13	15	832

Source: U.S. Census of Agriculture, 1969.

pattern of decreasing rural land surrounding the Akron-Cleveland metropolitan complex reveals the current as well as the future potential growth. Large areas of farmland are presently being developed for urban-suburban demands or retained in a non-productive holding by speculators anticipating future urban needs. It may be noted that Ashtabula County, immediately adjacent to the basin area, remains relatively rural with 43% of its land in farm use Inclusion of Ashtabula with the agricultural data presented for the basin counties provides an indication of the extreme rural contrast to the basin's urbanized character.

Although the total acreage and number of farms in the basin declined since the 1950's, the average acreage per farm has increased, thus indicating a maintenance of local productive capacity for the regional market. Among the major agricultural commodities of the basin counties relative to cash receipts rankings are dairy products, vegetables, poultry and some fruits (Table 8). Also, greenhouse and nursery cultivation comprise a relatively substantial portion of total farm marketings in Cuyahoga, Lake and Summit Counties--these counties were among the state's leading producers. Another major contribution to the state total is found in Portage County's potato production.

Although a rather drastic decline of land in farms has occured through the past decades, the current status of farming activities can be expected to remain relatively stable. However, the future of agricultural land use is in large part dependent on regional demands relative to external market access as well as the protection of farm acreage from encroachment urban development.

TABLE 7 Trends in Agricultural Land Use, 1954, 1959, 1964, & 1969.

	Farms (Number)				Average Size of Farm (Acres)			
	1954	1959	1964	1969	1954	1959	1964	1969
OHIO TOTAL	177,074	140,353	120,381	111,332	112.9	131.9	146.4	153.6
3-River Watershed Counties:								
Ashtabula	3,376	2,295	1,737	1,500	92.9	105.9	123.4	127.9
Cuyahoga	1,145	576	405	272	29.5	34.5	41.8	38.1
Geauga	1,682	1,014	804	578	93.5	114.0	119.0	120.2
Lake	1,225	783	523	306	49.7	58.7	66.6	69.1
Lorain	2,644	1,929	1,644	1,354	84.3	99.9	112.3	119.5
Medina	2,353	1,677	1,508	1,288	90.2	104.3	106.4	111.9
Portage	2,667	1,767	1,396	1,030	77.1	91.7	102.3	120.6
Summit	2,119	707	546	315	43.9	70.9	76.8	87.5

	Land in Farms (Acres)				Proportion of All Land Area in Farms			
	1954	1959	1964	1969	1954	1959	1964	1969
OHIO TOTAL	19,991,586	18,506,796	17,619,167	17,111,459	76.2%	70.6%	67.2%	65.2%
3-River Watershed Counties:								
Ashtabula	331,589	243,120	214,424	191,993	69.4	53.8	47.5	42.8
Cuyahoga	33,805	19,889	16,944	10,379	11.6	6.8	5.8	3.6
Geauga	157,319	115,563	95,664	69,527	60.4	44.4	36.7	26.7
Lake	60,873	45,929	34,839	21,159	41.0	30.9	23.4	14.3
Lorain	222,939	192,656	184,635	161,901	70.4	60.8	58.2	51.1
Medina	212,317	174,970	160,465	144,178	78.2	64.5	59.1	53.1
Portage	205,518	162,106	142,775	124,315	63.7	50.3	44.2	39.3
Summit	92,919	50,149	41,934	27,592	35.2	19.0	15.8	10.6

TABLE 8. Cash Receipts from Farm Marketings, and the Rank of the Eight Major Commodities by Relative Importance, Counties in the Three-Rivers Watershed Area, 1970 and 1962

County	Total Cash Receipts from Sales	EIGHT MAJOR COMMODITIES & PERCENTAGE OF TOTAL CASH RECEIPTS FROM SALES							
		RANK 1	RANK 2	RANK 3	RANK 4	RANK5	RANK 6	RANK 7	RANK 8
Ashtabula									
1970	$15,670	Dairy 50	Cattle 13	Gr&Nrs 10	Fruits 9	Vegs 4	Poultry 3	MiscCrops 2	Hay 2
1962	14,536	Dairy 49	Grh&Nurs 16	Fruits 10	Cattle 8	Poultry 5	Vegs 3	Wheat 2	Hay 1
Cuyahoga									
1970	10,084	Vegs 61	Grh&Nurs 33	Fruits 2	Poultry 2	Oth Livestk 1	Cattle 1	Dairy --	Forest --
1962	11,961	Grh&Nurs 47	Vegs 45	Fruits 2	Poultry 1	Cattle 1	Dairy 1	Soybns --	Hay --
Geauga									
1970	7,727	Dairy 42	Poultry 20	Cattle 11	Forest 8	Gr&Nrs 5	Hogs 5	Fruit 3	Hay 1
1962	4,669	Dairy 49	Cattle 14	Poultry 13	Fruits 6	Gr&Nrs 5	Hay 3	Forest 2	Hogs 2
Lake									
1970	9,567	Grh&Nurs 80	Fruits 8	Vegs 4	Poultry 3	Dairy 2	Cattle 1	Corn 1	Hay 1
1962	8,459	Grh&Nurs 73	Fruits 9	Vegs 5	Poultry 5	Dairy 2	Cattle 2	Wheat 1	Corn --
Lorain									
1970	19,006	Dairy 29	Vegs 24	Soybns 10	Cattle 10	Gr&Nrs 7	Fruits 5	Poultry 5	Corn 4
1962	15,613	Dairy 31	Vegs 25	Gr&Nrs 9	Soybns 7	Poultry 6	Cattle 6	Fruits 5	Wheat 4
Medina									
1970	12,567	Dairy 45	Cattle 16	Poultry 12	Hogs 5	Corn 4	Soybns 4	Vegs 3	Hay 2
1962	11,915	Dairy 49	Cattle 14	Poultry 14	Wheat 4	Hogs 4	Corn 4	Vegs 3	Soybns 2
Portage									
1970	11,283	Dairy 34	Vegs 15	Cattle 12	Poultry 11	Potatoes 6	Corn 4	Fruits 3	Oth Livestk 3
1962	9,975	Dairy 41	Cattle 11	Vegs 10	Poultry 10	Gr&Nrs 5	Potatoes 4	Wheat 4	Hogs 3
Summit									
1970	9,213	Grh&Nurs 71	Dairy 7	Vegs 6	Cattle 5	Poultry 3	Fruits 3	Oth Livestk 2	Corn 1
1962	7,700	Grh&Nurs 67	Dairy 10	Poultry 6	Vegs 5	Fruits 3	Cattle 3	Corn 1	Wheat 1

Source: Ohio Farm Income, 1962 and 1970, Agricultural Research and Development Center, Wooster, Ohio.

B. CHARACTERISTICS BY CATEGORY

1. Ecology Baseline Conditions

A summary of baseline conditions for aquatic ecosystems within the Three Rivers Watershed is shown in Tables 9, 10, and 11. These evaluations are based on the State of Ohio Stream Water Quality criteria. Chemical and physical water analyses have been emphasized because of the emphasis placed on these parameters in the water quality criteria. Most water quality surveys within the watershed have dealt exclusively with chemical and physical analyses. Data for the evaluation shown in Tables 9 , 10, and 11 were obtained from the most recent studies available. These include water quality studies by Havens and Emerson, Ltd., (1970a and 1970b), U.S Geological Survey (1971), University of Akron (1972), Long (1972), Center for Urban Regionalism (1972), Cooke (1968), and Page (1966).

A summary of baseline conditions for the Three Rivers Watershed in relation to benthic invertebrate water quality parameters is shown in Tables 12, 13, and 14. Benthic invertebrate surveys within the Three Rivers Watershed have been performed by Havens and Emerson, Ltd., (1970a, 1970b), University of Akron (1972), Long (1972), Page (1966), and the Center for Urban Regionalism (1972).

A list of fish now existing or known to have existed in the Three Rivers Watershed is shown in Table 15. Fish have been surveyed most extensively by the Ohio Division of Wildlife. Additional surveys of fish in the Three Rivers Watershed include those of Orr (1968), Havens and Emerson, Ltd., (1970a, 1970b), Center for Urban Regionalism (1972), and Page (1966).

Table 9. Baseline conditions in the Cuyahoga River Basin in relation to the State of Ohio Water Quality Standards. Code: (-) unacceptable, (+) acceptable, (o) data not available.

Waterway or section thereof	State of Ohio Water Quality Standards								All water must be free from:			
	Coliform bacteria	Temperature	pH	Threshold-Odor No.	Radioactivity	Dissolved Oxygen	Dissolved Solids	Other Chemicals	Toxic substances	Putrescent sludge	Floating debris	Nuisance odor
1. Cuyahoga upstream of Lake Rockwell and tributaries thereto	+	+	+	+	o	+	+	+	+	-	-	+
2. Lake Rockwell to State Route 17*	-	+	+	o	o	-	-	-	-	-	-	-
3. State Route 17 to Coast Guard Station	-	+	+	o	o	-	-	-	-	-	-	-
4. Little Cuyahoga River upstream of State Route 91 and downstream of Hazel Street	-	+	+	o	o	-	-	-	-	-	-	-
5. Little Cuyahoga River between Route 91 and Hazel Street, Summit Lake and Ohio Canal	-	-	+	o	o	-	-	-	-	-	-	-
6. All other tributaries between Lake Rockwell and Harvard Avenue	inconclusive											
7. For the following lakes, ponds, or reservoirs: Aquilla, Brady, Congress, Geauga, Hudson, Springs, Mogadore, Muddy, Muzzy, Punderson, Sandy, Snow, Springfield, Silver, Wyoga, Aurora Pond	inconclusive											
8. All other small lakes now used for swimming and water contact sports.	inconclusive											

*Temperature satisfactory except for a short distance below power plant.

Table 10 Baseline conditions in the Rocky River Basin in relation to the State of Ohio Water Quality Standards. Code: (-) unacceptable, (+) acceptable, (o) data not available.

Waterway or section thereof	State of Ohio Water Quality Standards											
									All water must be free from			
	Coliform bacteria	Temperature	pH	Threshold-Odor No.	Radioactivity	Dissolved Oxygen	Dissolved Solids	Other Chemicals	Toxic substances	Putrescent sludge	Floating debris	Nuisance odor
1. Rocky River and all tributaries	-	+	+	o	o	-	-	-	-	-	-	-
2. West Branch upstream of Route 3	-	+	+	o	o	+	-	o	+	-	-	+
3. North Branch of the West Branch downstream of Bagdad Road	-	+	+	o	o	+	+	o	+	-	-	+
4. East Branch in the vicinity of Baldwin Lake	-	+	+	o	o	+	+	o	inconclusive			
5. Baldwin Creek in the vicinity of Coe Reservoir	-	+	+	o	o	+	+	o	inconclusive			
6. All lakes being used for swimming or water contact sports	*											

* Some areas require chlorination to meet bacterial standards.

Table 11 Baseline conditions in the Chagrin River Basin in relation to the State of Ohio Water Quality Standards Code: (-) uacceptable, (+) acceptable, (o) data not available.

Waterway or section thereof	State of Ohio Water Quality Standards										All water must be free from	
	Coliform bacteria	Temperature	pH	Threshold-Odor No.	Radioactivity	Dissolved Oxygen	Dissolved solids	Other chemicals	Toxic substances	Putrescent sludge	Floating debris	Nuisance odor
1. Chagrin River and all tributaries	-	+	+	o	o	+	+	o	+	-	-	-
2. East Branch at its mouth	-	+	+	o	o	+	+	o	+	-	-	+
3. Main stem in the vicinity of Daniels Park	-	+	+	o	o	+	+	o	+	+	-	+
4. Main stem upstream from Chagrin Falls	-	-	+	o	o	-	+	o	+	+	-	+
5. Aurora Branch	-	-	+	o	o	-	+	o	+	-	-	+
6. East Branch	-	-	+	o	o	+	+	o	+	+	-	+
7. All lakes being used for swimming or water contact sports	-	+	+	o	o	+	+	o	+	+	-	+

Table 12 Summary of benthic invertebrate community-structure parameters for the Cuyahoga River.*

Station No. Km. from Lake Erie	Station Nearest Road	No. of Species	Shannon Diversity Index**	Beck Biotic Index***	% Pollution-Sensitive****	% Intermediate	% Pollution-Tolerant
43	Boston Mills Road	11	1.07	11	2.9	8.8	88.2
60	Bath Road	3	0.78	1	0.0	7.7	92.3
65	Akron-Penninsula Road	11	1.78	8	0.6	75.7	24.7
68	Gorge Metropolitan Park	14	1.83	12	0.7	92.1	7.2
80	Ohio Rte. 91	18	2.96	21	10.8	86.5	2.7
84	Middlebury Road	6	1.73	5	9.1	13.6	77.3
85	Longmere Drive	8	1.84	5	0.0	16.7	83.3
89	Standing Rock Cemetery	16	3.38	15	9.8	75.6	14.6
92	Ravenna Road	7	1.88	5	0.0	78.8	21.2
104	Colt Road	24	3.10	30	17.5	77.8	4.7
120	Winchell Road	39	3.80	49	24.0	72.0	4.0
127	U.S. Route 422	28	2.78	32	2.3	86.8	10.9
138	Ohio Route 87	18	3.25	18	7.3	85.4	7.3
141	Burton-Windsor Road	10	3.09	9	0.0	92.1	7.9

*Source of Data:

University of Akron, 1972. A biological evaluation of the Cuyahoga River. Report prepared by Biotest Laboratory, Dept. of Biology, University of Akron, Akron, Ohio.

**Wilhm, J. L., and T. C. Dorris, 1968. Biological parameters for water quality criteria. Bioscience 18:477-481.

***Beck, W. M., 1955. Suggested method for reporting biotic data. Sewage and Ind. Wastes 27:119?-1197.

****Mackenthun, K. M., 1969. The Practice of Water Pollution Biology. Federal Water Pollution Control Administration (Environmental Protection Agency), Washington, D.C.

Table 13 Summary of benthic invertebrate community-structure parameters for the Rocky River.*

Station No. Km. from mouth	Nearest Road	No. of Species	Beck Biotic Index **
Main Stem			
1.0	Detroit Road	5	3
15.75	Grayton Road (Abrams Cr.)	6	3
17.5	Park Road	10	6
East Branch			
0.3	Park Road Ford, Cedar Point	8	6
4.8	Park Road	4	3
8.5	Berea Water Intake	8	5
10.0	Bridge Street	5	3
13.0	Albion Park	5	5
31.8	Rte. 303	26	37
42.0	Rte. 303	16	20
West Branch			
19.0	Lewis Road	9	6
38.2	Rte. 82	15	14
55.0	Marks Road	7	7
64.0	U.S. Rte. 42	21	21
72.5	U.S. Rte. 18	14	13
75.0	Smith Road	15	13
North Branch (Km. from mouth)			
0.8	Granger Road below Medina Water Plant	4	3
0.9	Granger Road above Medina Water Plant	13	16

Table 13 (Cont.)

*Sources of Data:

Havens and Emerson, LTD, 1970. Water Quality of the Rocky and Chagrin Rivers. Report prepared for the Three Rivers Watershed District, Cleveland, Ohio.

Long, David C., 1972, A water quality survey of the Rocky River. Report prepared for Biotest Laboratory, University of Akron, Department of Biology.

** Beck, W. M., 1955. Suggested method for reporting biotic data. Sewage and Ind. Wastes 27:1193-1197.

Table 14 Summary of benthic invertebrate community-structure parameters for the Chagrin River.*

Station No. Km. from Mouth	Station Nearest Road	No. of Species	Shannon Diversity Index**	Beck Biotic Index***	% Pollution Sensitive****	% Intermediate	% Pollution Tolerant
Main Stem							
67.8	Butternut Road	19		22			
51.0	Dines Road	34	2.7	47	16.6	25.9	57.5
49.0	U.S. Rte. 87	40	4.1	53	15.8	71.1	13.1
44.1	Chagrin Falls Library	25	3.8	27	6.1	64.9	28.4
43.6	below falls	11	2.8	14	11.1	75.3	13.6
43.5	below sewerline	15	2.5	15	6.4	82.4	11.2
43.2	Washington Street	12	1.5	14	7.8	86.3	5.9
37.5	Chagrin Blvd.	13		11			
20.5	Mayfield Road	16		16			
8.5	Waite Hill Road	12		9			
1.5	Route 283	11		5			
East Branch							
E.B. 13.7	Kirtland Road	13		20			
E.B. 5.9	Markell Road	16		22			
Aurora Branch							
A.B. 11.0	Route 306	6		3			
A.B. 0.5	Chagrin River Road	18		22			
McFarland Creek							
M.C. .01	Chagrin River Road	24		31			

Table 14 (Cont.)

*Sources of Data:

Havens and Emerson, LTD, 1970. Water Quality of the Rocky and Chagrin Rivers. Report prepared for the Three Rivers Watershed District, Cleveland, Ohio.

Biotest Laboratory, 1972. Biological Water Quality Survey of the Upper Chagrin River. Special Report. Department of Biology, University of Akron.

** Wilhm, J. L. and T. C. Dorris, 1968. Biological parameter for water quality criteria. Bioscience 18:477-481.

*** Beck, W. M., 1955. Suggested method for reporting biotic data. Sewage and Ind. Wastes 27:1193-1197.

**** Mackenthun, K. M., 1967. The Practice of Water Pollution Biology. Federal Water Pollution Control Administration (Environmental Protection Agency), Washington, D. C.

Table 15 Fish now existing or known to have existed in the Cuyahoga River, Rocky River, and Chagrin River.*

	Chagrin	Cuyahoga	Rocky
Agnatha - Petromyzontidae			
Silver Lamprey - Ichtyomyzon unicuspis (Hubbs & Trautman)		X	
Clupeidae			
Eastern Gizzardshad - Dorosoma cepedianum (Le Sueur)	X	X	
Sàlmonidae			
Brown Trout - Salmo trutta Linnaeus (introduced)	X		
Rainbow Trout - Salmo gairdenri Richardson (introduced)	X		
Umbridae			
Central Mudminnow - Umbra limi (Kirtland)	X	X	X
Esocidae			
Central Redfin Pickerel - Esoc americanus vermiculatus (Le Suer)	X	X	X
Catostomidae			
Central Quillback Carpsucker - Carpiodes cyprinus hinei (Trautman)		X	
Common White Sucker - Catostomus commersoni commersoni (Lacepede)	X	X	X
Golden Redhorse - Moxostoma erythrurm (Rafinesque)	X	X	X
Hog Sucker - Hypentelium nigricans (Le Sueur)	X	X	X
Spotted Sucker - Minytrema melanops (Rafinesque)		X	X
Western Lake Chubsucker Erimyzon sucetta Kennerlyi (Girard)		X	

Table 15 (cont.)

	Chagrin	Cuyahoga	Rocky
Cyprinidae			
Bluntnose Minnow - *Pimephales promelas promelas* (Rafinesque)	X	X	X
Carp - *Cyprinus carpio* Linnaeus	X	X	X
Central Bigmouth Shiner - *Notropis dorsalis dorsalis* (Agassiz)			X
Central Stoneroller Minnow - *Campostoma anomalum pullum* (Agassiz)	X		X
Common Emerald Shiner - *Notropis antherinoides antherinoides* (Rafinesque)	X		X
Common Shiner - *Notropis cornutus* (Mitchill)	X	X	X
Goldenshriner - *Notemigonus crysoleucas* (Mitchill)	X	X	X
Goldfish - *Carassius auratus* (Linnaeus)	X	X	X
Hornyhead Chub - *Hybopsis biguttata* (Kirtland)	X	X	
Longnose Dace - *Rhinichthyes atratulus meleagris* (Agassiz)	X		
Northeastern Sand Shiner - *Notropis stramineus stramineus* (Cope)	X	X	X
Northern Bigeye Chub - *Hybopsis amblops amblops* (Rafinesque)	X		X
Northern Creek Chub - *Semotilus atromaculatus atromaculatus* (Mitchill)	X	X	X
Northern Fathead Minnow - *Pimephales promelas promelas* (Rafinesque)		X	
Northern Mimic Shiner - *Notropis volucellus volucellus* (Cope)		X	X
Northern Redfin Shiner - *Notropis umbratilis cyanocephalus* (Copeland)	X	X	
Northern Striped Shiner - *Notropis chrysocephalus chrysocephalus* (Rafinesque)	X	X	X

Table 15 (cont.)

	Chagrin	Cuyahoga	Rocky
Ohio Spotted Chub - *Hybopsis dissimilis dissimilis* (Kirtland - before 1900)	X		
Ohio Stoneroller Minnow - *Camposta anomalum anomalum* (Rafinesque)	X		X
Redside Dace - *Clinostomus elongatus* (Kirtland)	X	X	X
River Chub - *Hybopsis micropogon* (Cope - prior to 1937)	X	X	X
Rosyface Shiner - *Notropis rubellus* (Agassiz)	X	X	X
Silver Chub - *Hybopsis storeriana* (Kirtland)			X
Silverjaw Minnow - *Erycymba buccata* (Cope)	X		
Spotfin Shiner - *Notropis spilopterus* (Cope)	X	X	X
Southern Redbelly Dace - *Chrosomus erythrogaster* (Rafinesque)	X	X	X
Western Blacknose Dace - *Rhinichthyes atratulus meleagris* (Agassiz)	X	X	X
Ictaluridae			
Black Bullhead - *Ictalurus melas* (Rafinesque)	X	X	X
Brown Bullhead - *Ictalurus natalis* (Le Sueur)	X	X	X
Channel Catfish - *Ictalurus punctatus* (Rafinesque)	X	X	X
Stonecat Madtom - *Noturus flavus* (Rafinesque)	X		X
Tadpole Madtom - *Noturus gyrinus* (Mitchill)	X		
Yellow Bullhead - *Ictalurus natalis* (Le Sueur)	X	X	
Percopsidae			
Troutperch - *Percopsis omiscomaycus* (Walbaum)		X	X
Antherinidae			
Brook Silversides - *Labidesthes sicculus* (Cope)	X	X	

Table 15 (cont.)

	Chagrin	Cuyahoga	Rocky
Serranidae			
White Bass - Roccus chrysops (Rafinesque)	X	X	X
Centrarchidae			
Black Crappie - Pomoxis nigromaculatus (Le Sueur)		X	X
Green Sunfish - Lepomis cyanellus (Rafinesque)	X	X	X
Northern Bluegill Sunfish - Lepomis macrochirus macrochirus (Rafinesque)	X	X	X
Northern Largemouth Blackbass - Micropterus salmoides salmoides (Lacepede)	X	X	X
Northern Rockbass - Ambloplites rupestris rupestris (Rafinesque)	X	X	X
Northern Smallmouth Blackbass - Micropterus dolomieui dolomieui (Lacepede)	X	X	X
Pumpkinseed Sunfish - Lepomis gibbosus (Linnaeus)	X	X	X
Redear Sunfish - Lepomis microlophus (Gunther)		X	X
Warmouth Sunfish - Chaenobryttus gulosus (Cuvier)	X	X	
White Crappie - Pomoxis annularis (Rafinesque)	X	X	X
Percidae			
Barred Fantail Darter - Etheostoma flabellare flabellare (Rafinesque)	X	X	X
Blackside Darter - Percina maculata (Girard)	X	X	X
Blue Walleye - Stizostedion vitreum glaucum (Hubbs)	X		
Central Johnny Darter - Etheostoma nigrum nigrum (Rafinesque)	X	X	X
Channel Darter - Percina copelandi (Jordan)	X		
Eastern Sand Darter - Ammocrypta pellucida (Baird)			X
Greenside Darter - Etheostoma blennioides (Rafinesque)	X	X	X
Iowa Darter - Etheostoma exile (Griard)	X	X	

Table15 (cont)

	Chagrin	Cuyahoga	Rocky
Ohio Logperch Darter - <u>Percina caprodes caprodes</u> (Rafinesque)		X	
Rainbow Darter - <u>Etheostoma caeruleum</u> (Storer)	X	X	X
Sauger - <u>Stizostedion canadense</u> (Smith)	X	X	X
Yellow Perch - <u>Perca flavescens</u> (Mitchill)	X	X	X
Yellow Walleye - <u>Stizostedion vitreum vitreum</u> (Mitchill)	X		
Sciaenidae			
Freshwater Drum - <u>Aplodinotus grunniens</u> (Rafinesque)	X		
Cottidae			
Central Redfin Scuplin - <u>Cottus bairdi bairdi</u> (Girard)	X	X	
Gasterosteidae			
Brook Stickleback - <u>Culaea inconstans</u> (Kirtland)	X	X	

*Sources:

1. Havens and Emerson, Ltd, 1970. Water Quality of the Rocky and Chagrin Rivers. Report prepared for the Three Rivers Watershed District, Cleveland, Ohio.

2. Trautman, M.B. 1957. <u>The Fishes of Ohio</u>. The Ohio State University Press, Columbus, Ohio, 683 p.

Aquatic vascular plants and phytoplankton have not been studied extensively within the waterways of the Three Rivers Watershed. Some of the most recent studies include those of Marshall (1965), Rhodes (1968), Olive (1968), Page (1971), and Long (1971). The results of these studies will not be summarized here because of difficulties in relating the results to present water quality standards and because of the relatively small areas covered by the studies.

Bacterial surveys and chemical-physical water quality analyses have been conducted by Havens and Emerson, Ltd., (1970a, 1970b), U.S. Geological Survey (1971), Center for Urban Regionalism (1972), and University of Akron (1972). Tables 16 and 17 summarize recent bacterial analyses of the Chagrin and Rocky Rivers. Recent chemical and physical water quality analyses of the Cuyahoga, Rocky, and Chagrin Rivers are summarized in Tables 18 , 19, 20, and 21.

a . Baseline Conditions for the Cuyahoga River

Baseline conditions for the Cuyahoga River are shown in Table 3. Water quality in the Cuyahoga River above Lake Rockwell is relatively good. Except for small areas of putrescent vegetative materials and excessive floating debris, this section of the river usually meets Ohio Stream Water Quality Standards.

Between Lake Rockwell and the City of Akron, the river is adversely affected by (1) withdrawal of water for the City of Akron (2) limited waste leakage from the Akron Water Treatment Plant. (3) small metal plating industries in the City of Kent (4) effluent

Table 16 Bacteriological Data of Rocky River - 1969-70*

Numbers per 100 ml

Station	Total Coli	Fecal Coli	Fecal Strep
Station #1			
Boat Landing South of Detroit Road Bridge			
Average	27,850	3,875	8,738
Extreme Max.	830,000	28,250	32,450
Extreme Min.	325	5	110
No. of Samples	19	19	8
Station #3			
Road Downstream of Confluence of East & West B.anch			
Average	59,743	2,908	6,781
Extreme Max.	300,000	104,000	32,550
Extreme Min.	5,000	540	882
No. of Samples	14	14	6
Station #4			
West Branch - Lewis Rd.			
Average	28,890	1,956	1,683
Extreme Max.	76,000	9,400	6,300
Extreme Min.	2,650	350	315
No. of Samples	18	18	5
Station #5			
East Branch - Park Rd.			
Average	109,711	14,124	6,997
Extreme Max.	805,000	97,000	22,350
Extreme Min.	4,000	550	125
No. of Samples	20	20	7
Station #6			
West Branch Rte. 82			
Average	19,704	464	373
Extreme Max.	85,000	12,200	640
Extreme Min.	760	100	160
No. of Samples	11	10	4
Station #6a			
West Branch Marks Rd.			
Average	87,866	5,607	6,915
Extreme Max.	377,750	86,950	14,550
Extreme Min.	2,400	100	100
No. of Samples	22	22	9

Table 16 (continued)

	Total Coli	Fecal Coli	Fecal Strep
Station #7			
West Branch - Fenn Rd.			
Average	34,327	1,259	2,552
Extreme Max.	235,000	4,860	12,300
Extreme Min.	1,800	164	100
No. of Samples	17	17	6
Station #8			
West Branch - Smith Rd.			
Average	13,400	458	547
Extreme Max.	25,400	875	607
Extreme Min.	2,200	366	302
No. of Samples	9	9	3
Station #9			
North Branch - Granger Rd.			
Average	22,977	689	1,324
Extreme Max.	69,200	5,175	4,800
Extreme Min.	840	46	361
No. of Samples	14	13	5
Station #10			
East Branch - Bridge St.			
Average	11,707	877	995
Extreme Max.	85,000	6,700	3,975
Extreme Min.	90	120	28
No. of Samples	25	25	5

	Total Coli	Fecal Coli	Fecal Strep
Station #11			
East Branch Downstream of Hinckley Lake on Center Road			
Average	2,294	214	429
Extreme Max.	4,110	357	630
Extreme Min.	210	41	192
No. of Samples	11	11	4
Station #12			
East Branch Upstream of Hinckley Lake on Center Road			
Average	1,414	306	831
Extreme Max.	3,650		1,935
Extreme Min.	600	66	100
No. of Samples	7	6	3

*DATA SOURCE: Three Rivers Watershed District, Cleveland, Ohio. A report of Water Quality in the Rocky and Chagrin Rivers prepared by Havens & Emerson, Ltd., Consultin Engineers, Cleveland, Ohio. 1970.

Table 17 . Bacteriological Data of Chagrin River 1969-70*

Numbers per 100 ml

Station	Total Coli	Fecal Coli	Fecal Strep
Station #1			
Main Stem Route 283 Bridge			
Average	8,999	2,054	630
Extreme Max.	280,000	54,000	2,060
Extreme Min.	900	30	35
No. of Samples	18	18	5
Station #2			
Main Stem - Waite Hill Road			
Average	4,800	2,200	200
Extreme Max.	380,000	14,000	1,400
Extreme Min.	100	30	110
No. of Samples	25	24	9
Station #3			
East Branch - Markell Road			
Average	5,300	500	100
Extreme Max.	75,000	3,100	120
Extreme Min.	90	10	1
No. of Samples	25	25	4
Station #4			
Main Stem - Mayfield Rd. in Gates Mills			
Average	6,400	1,100	180
Extreme Max.	64,000	8,200	
Extreme Min.	1,850	80	
No. of Samples	15	15	3

Station	Total Coli	Fecal Coli	Fecal Strep
Station #5			
Main Stem - Chagrin Blvd.			
Average	8,500	2,206	1,700
Extreme Max.	37,000	8,100	3,000
Extreme Min.	3,400	450	70
No. of Samples	24	24	7
Station #6			
Aurora Branch - Chagrin River Road			
Average	3,600	500	260
Extreme Max.	76,000	4,800	450
Extreme Min.	250	10	50
No. of Samples	25	25	7
Station #7			
Main Stem, Rt. 87 near Russell Center			
Average	2,200	400	130
Extreme Max.	7,800	1,800	250
Extreme Min.	450	90	100
No. of Samples	19	19	5
Station #8			
Aurora Branch Rt. 306 North of Aurora			
Average	17,000	6,500	
Extreme Max.	170,000	12,000	1,000
Extreme Min.	8,800	4,400	1,000
No. of Samples	3	3	1

Table 17 (continued)

	Total Coli	Fecal Coli	Fecal Strep
Station #9			
McFarland Creek at Chagrin River Road			
Average	2,000	480	150
Extreme Max.	62,000	2,100	150
Extreme Min.	30	20	150
No. of Samples	10	10	1
Station #10			
Main Stem - Butternut Rd. near Fowlers Hill			
Average	1,300	290	230
Extreme Max.	15,000	3,300	1,000
Extreme Min.	200	80	100
No. of Samples	8		4
Station #11			
East Branch - Kirtland Rd.			
Average	1,420	147	300
Extreme Max.	6,900	2,100	3,400
Extreme Min.	60	5	20
No. of Samples	11	11	5

*DATA SOURCE: Three Rivers Watershed District, Cleveland, Ohio. A report of Water Quality in the Rocky and Chagrin River prepared by Havens and Emerson, Ltd., Consulting Engineers, Cleveland, Ohio.

Table 18 Chemical and Physical Water Quality Data for the Cuyahoga River, April-May, 1972. Concentration in mg/1.*

Station Kilometers from Lake Erie	Location	T. Alkalinity	Carbon Dioxide	Chloride	Chromate	Copper	Fluoride	T. Hardness	Iron	Manganese	Nitrate - N	Oxygen	T. Phosphate	Silica	Sulfate	Turbidity (JTU)	pH	Temperature (°C)
43	Boston Mills Road	130						180				8.2	2.6				8.2	18
60	Bath Road	130	36	165	0	.1	.4	210	.3	.7	4.8	6	18	5.4	190	20	8.0	18
65	Akron-Peninsula Road	80	12	100	.3	0	.3	150	.3	0	9	10	1.2	2.1	83	23	8.7	18
68	Gorge Metropolitan Park	130	84									10					8.2	19
80	Ohio Rte. 91	130	80									10					8.4	16
84	Middlebury Road	130	12	65	.3	0	.3	190	.3	0	9	8		2.1	83	23	8.0	18
85	Longmere Drive	160	35	90	0	.1	.1	250	.3	.3	30	13	1.4	1.3	48	10	6.5	18
89	Standing Rock Cemetry	70	0	275	0	.1	.1	115	.05	.7	20	16	.2	5.6	48	20	8.0	16
92	Ravenna Road	60	0	30	.1	0	.1	110	.06	1.4	21		.2	1.6	42	1	8.2	16
104	Colt Road	60	4	25	0	0	.1	110	.4	0	6	12	4.3		42	20	8.2	12
120	Winchell Road	60	4	30	0	.1	.6	100	.4	0	6	11	2.1	2.1	47	19	8.2	10
127	U.S. Route 422	70	4	30	.2	.2	.1	100	.4	.7	10	11	0.3				7.6	10
138	Ohio Route 87	230	8	50	.1	.7	.6	300	.6	2.2	20	10		2.0	40	30	8.4	10
141	Burton-Windsor Road	50	8	50	.1	0	.1	80	.2	.4	60	12		.6	28	27	8.2	10

*Source of data: Biotest Laboratory, 1972. A biological evaluation of the Cuyahoga River. Special Report, Department of Biology, University of Akron, Akron, Ohio.

Table 19 Water Quality Data of Rocky River 1969-70*

Concentration mg/l

Station	Temp. °F	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	NO_3	K_jN	Total PO_4	SO_4	Cl
Rocky River #1													
Boat Landing South of Detroit Road Bridge													
Average	61	7.4	6.7	33	471	65	416	7.6	2.51	5.36	9.27	97	65
Extreme Max.	78	13.0	15.0	63	659	306	478	7.9	4.95	6.32	17	131	81
Extreme Min.	36	3.8	3.9	7.7	375	7.0	318	7.4	1.25	3.34	1.1	70	45
No. of Samples	20	20	20	20	20	20	20	20	20	20	20	20	20
Rocky River #3													
Road Downstream of Confluence of East & West Branch													
Average	55	9.2	6.2	31	491	88	424	7.8	2.27	2.96	5.15	80	59
Extreme Max.	75	14.0	10.0	61	672	346	522	8.1	4.7	3.44	11.0	148	84
Extreme Min.	33	5.8	2.4	5.1	378	13	326	7.4	.23	2.22	3.0	13	36
No. of Samples	15	15	15	15	15	5	5	15	13	3	13	5	4
Rocky River #4													
West Branch - Lewis Rd.													
Average	53	9.6	4.6	24	519	44	505	8.1	1.31	2.86	3.76	111	102
Extreme Max.	77	8.2	10.1	49	705	138	680	8.6	2.6	11.0	7.9	170	183
Extreme Min.	33	8.2	1.0	8.8	243	5	282	7.6	.38	.09	.90	10	35
No. of Samples	18	18	19	18	13	13	19	13	5	17		10	13

Table 19 (continued)

	Temp. °F	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	NO_3	K_jN	Total PO_4	SO_4	Cl
Rocky River #5													
East Branch - Park Road													
Average	53	10.0	5.2	30	500	47.1	464	7.8	1.74	4.58	8.07	127	97
Extreme Max.	75	14.0	14.0	76	630	447	823	8.2	4.9	7.5	25	163	291
Extreme Min.	33	5.2	1.3	1.9	358	1.0	307	7.4	.05	2.4	1.60	87	41
No. of Samples	20	19	21	21	20	14	13	21	14	8	18	11	13
Rocky River #6													
West Branch Route 82													
Average	58	8.3	4.0	26	578	49	549	7.8	.89	1.36	5.23	120	93
Extreme Max.	78	12.0	8.9	46	772	177	668	8.3	2.0	2.2	14.9	154	151
Extreme Min.	33	5.7	2.1	5.1	303	19	126	7.7	.05	.70	.54	47	30
No. of Samples	12	12	11	12	12	5	5	12	11	5	11	6	6
Rocky River #6a													
West Branch Marks Road													
Average	53	7.8	6.9	32	739	37	650	7.7	2.19	3.27	10.40	149	124
Extreme Max.	77	12.7	13.0	66	1160	74	875	8.5	6.0	4.28	24.75	197	273
Extreme Min.	33	3.3	1.8	.60	476	0	365	7.5	.05	1.6	1.2	115	15
No. of Samples	22	22	23	23	21	10	10	23	18	6	19	10	13
Rocky River #7													
West Branch - Fenn Rd.													
Average	54	7.1	6.0	39	739	49	859	7.6	1.42	4.92	10.15	144	199
Extreme Max.	77	12.7	9.7	73	1366	97	1316	8.0	2.9	6.3	28	169	537
Extreme Min.	33	3.0	1.6	13	184	9.0	376	7.4	.12	3.5	1.3	107	49
No. of Samples	18	17	18	18	18	8	8	17	17	6	15	6	7

Table 19 (continued)

	Temp. F°	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	NO_3	K_jN	Total PO_4	SO_4	Cl
Rocky River #8													
West Branch - Smith Rd.													
Average	66	6.8	3.1	29	701	33	706	8.0	.30	1.57	1.10	185	100
Extreme Max.	73	11.7	5.1	57	860	86	826	8.4	.45	.80	2.0	224	156
Extreme Min.	33	5.0	1.8	3	485	9	488	7.7	0.00	.09	.39	134	48
No. of Samples	9	9	9	9	8	7	6	9	6	5	7	5	6
Rocky River #9													
North Branch - Granger Road													
Average	61	9.2	3.2	22	457	50	402	8.0	.32	.56	.33	114	35
Extreme Max.	79	14.3	6.3	37	538	81	454	8.3	1.35	.79	1.40	137	51
Extreme Min.	33	5.8	1.0	3.8	393	30	312	7.6	0.00	.08	0.00	82	25
No. of Samples	14	14	13	14	13	7	7	14	9	5	11	7	8
Rocky River #10													
East Branch - Bridge St.													
Average	56	8.6	4.5	21	440	35	498	7.7	.80	.91	1.07	125	77
Extreme Max.	77	14.8	10	41	583	95	576	7.9	1.46	1.5	5.9	153	265
Extreme Min.	33	3.0	1.6	1.5	381	2	334	7.5	.18	.03	.36	91	31
No. of Samples	25	25	26	26	25	14	14	26	20	7	26	12	15
Rocky River #11													
East Branch Downstream of Hinckley Lake on Center Road													
Average	57	9.3	2.1	19	330	76	282	7.9	.60	.39	.20	55	20
Extreme Max.	76	14.2	4.0	39	351	85	268	8.1	.80	.59	.29	62	21
Extreme Min.	33	6.2	.60	5.0	296	66	256	7.7	.40	.19	0.00	46	18
No. of Samples	11	10	5	5	5	4	4	5	2	2	4	4	4

Table 19 (continued)

Rocky River #12	Temp. F°	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	No_3	K_jN	Total PO_4	SO_4	Cl
East Branch Upstream of Hinckley Lake on Center Road													
Average	53	10.9	1.9	16	354	19	318	7.9	.89	.31	.43	83	35
Extreme Max.	66	13.6	4.5	40	401	24	330	8.1	3.5	.38	.81	84	41
Extreme Min.	33	8.6	.2	0.0	309	15	307	7.8	.05	.27	.14	82	28
No. of Samples	8	8	8	8	8	2	2	8	7	4	7	2	2
Rocky River #2													
Average		5.9	9.2	71	503	39	459	7.9	35.6	18.2	13.5	90	69.7
Extreme Max.		7.2	9.4	73	503	45	475	7.9	52.8		13.6	104	74
Extreme Min.		5.4	8.5	63	502	27	451	7.8	1.2		13.4	83	67.5
No. of Samples		4	4	4	4	3	3	4	3	1	3	3	3

*DATA SOURCE: Three Rivers Watershed District, Cleveland, Ohio. A report of Water Quality in the Rocky and Chagrin Rivers prepared by Havens and Emerson, Ltd., Consulting Engineers, Cleveland, Ohio. 1970.

Table 20. Average Water Quality Data of Chagrin River 1969-70*

Concentration in mg/l

Station	Temp. F°	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	NO_3	K_jN	Total PO_4	SO_4	Cl
Chagrin River #1													
Main Stem Route 283 Bridge													
Average	58	9.0	5.4	19	372	147	296	7.9	.29	.55	.60	65	34
Extreme Max.	79	14.4	11	40	886	744	366	8.5	.90	.71	2.23	76	82
Extreme Min.	33	5.0	1.8	2.0	260	17	142	7.5	.05	.43	.02	52	5.0
No. of Samples	18	18	18	17	18	6	6	18	14	7	17	7	8
Chagrin River #2													
Main Stem - Waite Hill Road													
Average	56	9.9	4.0	18	386	23	338	8.0	.39	.49	.63	59	54
Extreme Max.	82	14.5	10	37	1036	907	446	8.8	.90	.86	1.4	77	123
Extreme Min.	33	6.5	1.0	3.8	282	3.0	129	7.2	.12	.35	.14	29	5.0
No. of Samples	25	25	24	24	23	11	12	23	17	8	23	13	14
Chagrin River #3													
East Branch - Markell Rd.													
Average	54	10.9	3.2	15	386	42	304	8.1	.36	.46	.25	72	23
Extreme Max.	73	14.5	9.7	86	1250	219	371	8.7	.65	1.8	3.2	98	33
Extreme Min.	33	6.0	.20	0.00	232	0	207	7.4	0.00	.11	0.00	44	11
No. of Samples	24	24	25	23	23	9	10	23	12	7	21	14	14
Chagrin River #4													
Main Stem - Mayfield Rd. in Gates Mills													
Average	51	8.9	3.5	29	288	40	258	7.9	.34	.56	.69	51	31
Extreme Max.	73	14.6	9.9	149	324	92	382	6.4	.80	.84	1.20	59	84
Extreme Min.	33	4.5	.40	5.7	242	3.0	150	7.6	.05	.38	.22	37	10
No. of Samples	15	15	15	15	12	5	6	15	10	7	12	9	9

Table 20 (continued)

	Temp. F°	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	No_3	K_jN	Total PO_4	SO_4	Cl
Chagrin River #5													
Main Stem - Chagrin Blvd.													
Average	54	9.6	3.6	22	278	50	235	7.8	.44	.72	.91	45	29
Extreme Max.	72	14.6	10.0	71	321	106	306	8.4	.70	1.01	1.75	60	64
Extreme Min.	33	5.5	0.9	11	218	0	126	7.5	.05	0.00	.03	36	11
No. of Samples	23	23	24	24	24	12	13	22	19	8	19	14	15
Chagrin River #6													
Aurora Branch - Chagrin River Road													
Average	52	9.5	3.4	19	288	36	258	8.0	.56	.42	.81	45	24
Extreme Max.	70	14	10	47	370	100	300	8.6	3.7	.83	2.2	64	50
Extreme Min.	33	4.0	0.00	2.4	233	0	146	7.5	.05	.19	.22	33	7.0
No. of Samples	24	24	24	25	23	13	14	24	18	9	23	14	15
Chagrin River #7													
Main Stem, Rt. 87 near Russell Center													
Average	54	10.4	3.8	16	215	17	202	7.8	.18	.41	.33	25	14
Extreme Max.	70	14.6	12.0	33	282	33	241	8.4	.51	.96	.70	38	22
Extreme Min.	33	5.5	.40	3.8	154	2.0	121	7.5	.05	.11	.14	21	10
No. of Samples	19	19	19	19	18	0	0	19	14	9	16	9	8
Chagrin River #8													
Aurora Branch Rte. 306 North of Aurora													
Average	66	7.8	1.7	19	237	51	205	7.7	.60	.72	.99	41	9.5
Extreme Max.	68	8.6	2.8	33	308	87	293	7.8	.65	1.1	1.10	48	13
Extreme Min.	63	7.0	.10	3.1	199	15	118	7.6	.55	.34	.88	35	6.0
No. of Samples	3	3	3	3	3	2	2	3	2	2	2	2	2

Table 20 (continued)

Chagrin River #9	Temp. F°	DO	BOD	COD	Total Solids	Susp. Solids	Diss. Solids	pH	NO_3	KjN	Total PO_4	SO_4	Cl
McFarland Creek at Chagrin River Road													
Average	51	10.4	3.9	14	249	40	194	7.7	.54	.22	.28	36	20
Extreme Max.	67	14.6	9.9	25	351	93	232	8.1	.95	.32	.58	47	30
Extreme Min.	33	7.2	.50	0.00	181	3.0	149	7.2	0.00	.10	.08	29	10
No. of Samples	10	10	10	9	10	3	3	10	8	3	9	4	4
Chagrin River #10													
Main Stem - Butternut Road near Fowlers Mill													
Average	56	9.9	2.8	19	215	52	149	7.8	.22	.39	.49	25	15
Extreme Max.	73	14.0	4.9	37	352	107	230	8.4	.50	.50	1.3	29	21
Extreme Min.	33	7.1	1.8	7.3	120	0	68	7.3	.05	.33	.14	22	10
No. of Samples	8	8	8	8	8	3	3	7	7	3	7	3	3
Chagrin River #11													
East Branch - Kirtland Road													
Average	58	9.5	2.6	14	312	27	285	8.0	.10	.25	.25	58	15
Extreme Max.	68	14.0	5.7	43	339	95	345	8.7	.30	.35	.60	76	26
Extreme Min.	38	6.5	.03	.40	297	6.0	207	7.4	0.00	0.00	.08	35	9.(
No. of Samples	11	11	11	11	11	6	6	10	8	5	10	6	6

* DATA SOURCE: Three Rivers Watershed District, Cleveland, Ohio. A report of Water Quality in the Rocky and Chagrin Rivers prepared by Havens and Emerson, Ltd., Consulting Engineers, Cleveland, Ohio. 1970.

Table 21 Water Quality Data for Major Tributaries to the Cuyahoga River*

SAMPLE SOURCE	STATION	YEAR	NUMBER OF RUNS		TEMP. °F	DO mg/l	BOD$_5$ mg/l	COD mg/l	TOTAL SOLIDS mg/l	SUSP. SOLIDS mg/l	DISS. SOLIDS mg/l	pH	NO_3 N mg/l	Kjel.N mg/l	TOTAL PHOS. mg/l	SO_4 mg/l	Cl mg/l	TOTAL COLIF Per 100 ml	FECAL COLIF Per 100 ml
TINKERS CREEK																			
Dunham Road	1	1967	5	Ave.	71.6	9.6	6.7	30	505	15	490		5.78	> .65	2.58	123	90	140,000	
				Max.	75.2	10.0	10.0	36	677	24		7.7	7.76		3.55			480,000	
				Min.	68.9	9.1	3.8	21	421	7		7.0	73		1.47			14,000	
Dunham Road	1	1969	4	Ave.	70.6	8.4	9.2	56	458	53	405		56	2.73	2.75	51	34	578,600	229,000
				Max.	72.5	9.0	17.0	96	728	83	661	7.9	1.00	4.82		89	81	1,090,000	345,000
				Min.	69.4	7.7	3.0	34	196	9	113	7.6	.20	1.29		32	6	56,000	0
Dunham Road	1	1967-69		Ave.	71.1	9.0	7.8	42	484	32	452		3.46		2.65	91	65	335,000	
Richmond Road	2	1969	4	Ave.	70.3	3.9	10.1	54	377	20	367		.17	1.85	1.87	46	60	1,245,000	127,[illegible]
				Max.	71.4	6.0	21.0	92	498	40	505	7.8		3.24		76	91	3,[illegible],000	291,[illegible]
				Min.	68.9	2.5	4.0	33	159	5	118	7.2		1.08		27	8	47,000	[illegible]
Glenwood Drive	3	1969	5	Ave.	69.3	4.5	5.9	42	315	19	296		.20	2.09	1.45	42	32	[illegible]	6,[illegible]
				Max.	72.9	6.7	8.0	89	423	29	409	7.9		3.1		74	50	[illegible]	31,450
				Min.	65.3	1.0	3.0	15	167	12	138	7.2		.97		23	9	[illegible],000	200
Twinsburg SOM Center	4	1969	5	Ave.	69.4	5.5	3.0	25	321	13	301		.70	.87	.26	45	29	21,100	1,[illegible]
				Max.	72.5	7.3	6.0	46	409	21	404	8.0			.30	79	43	[illegible],000	3,400
				Min.	65.3	4.0	.6	14	147	4	126	7.1			.21	28	9	11,500	360
Rte.14 at Summit-Portage	5	1969	5	Ave.	52.8	6.1	2.8	18	513	38	475		.97	.98	.65	83	52	40,900	6,450
				Max.	66.2	8.7	6.0	27	605	46	561	8.1	1.05			110	72	85,000	16,000
				Min.	52.3	4.5	.8	12	471	26	437	7.5	.85			49	46	18,000	1,400
Rte.303	6	1969	5	Ave.	62.2	6.7	3.1	18	522	53	469		.44	.80	.76	92	38	41,570	6,640
				Max.	64.4	7.4	7.0	29	550	80	541	8.0	.50			128	53	70,000	15,710
				Min.	60.8	5.4	.7	9	494	9	425	7.4	.40			48	29	13,950	3,600
Pond Brook	7	1969	5	Ave.	66.0	3.9	3.0	37	219	14	204		.09	.75	.40	26	16	28,390	770
				Max.	73.2	12.0	5.0	46	317	20	302	7.8	.10	1.09		31	26	68,500	2,100
				Min.	59.5	1.0	.9	24	122	8	114	6.6	.08	.38		22	9	5,100	110
BRANDYWINE CREEK																			
Jaite Mill	1	1969	4	Ave.	69.3	8.0	14.3	71	511	56	454		.88	1.84	3.64	107	46	361,750	168,500
				Max.	71.6	10.5	30.0	96	618	76	560	7.8	1.50	1.49		121	71	620,000	500,000
				Min.	66.0	6.4	8.0	52	401	34	367	7.6	.40	2.25		91	26	260,000	2,500
Old Route 8	2	1969	4	Ave.	68.9	3.7	8.5	293	4,721	4,252	469		1.03	•16.82	1.68	120	52	455,700	108,500
				Max.	71.6	7.1	15.0	790	13,271	12,699	572	7.6	1.20			154	81	800,000	380,000
				Min.	67.1	.5	4.0	40	411	23	388	7.3	.85			94	26	77,000	6,900
Hines Hill Rd.	3	1969	4	Ave.	66.4	5.2	4.8	41	403	22	382		1.50	6.16	φ14.90	70	48	2[illegible],875	1,640
				Max.	72.7	8.8	19.0	48	568	26	550	7.7	2.00	12.20		95	63	45,000	6,000
				Min.	59.0	1.5	5.0	35	300	16	279	7.6	.80	2.95		54	18	18,000	100
Prospect Rd.	4	1969	4	Ave.	65.1	6.9	4.2	28	550	116	433		.47	1.22	.78	65	88	80,250	3,375
				Max.	69.4	11.2	7.3	44	637	316	529	8.4	1.00			80	122	290,000	10,[illegible]
				Min.	59.0	0	1.6	20	456	5	321	7.6	.17			53	64	4,000	800
SAGAMORE CREEK																			
Canal Rd.	1	1967	7	Ave.	73.2	6.5	4.1	20	468	18	450			> .83	.85	102	168	110,000	72,000
				Max.	78.8	8.0	6.0	26	680	61	619	8.0		1.21		102	220	300,000	234,000
				Min.	68.9	5.5	2.7	11	413	3	410	6.9		.53		102	117	7,000	10,000
Canal Rd.	1	1969	2	Ave.	70.7	7.7	3.6											160,500	21,500
				Run 1	71.6	9.6	4.0					7.5						310,000	43,000
				Run 2	69.8	5.8	3.2	32	348	10	338	7.6	.80	.77		73	34	11,000	0
Canal Rd.	1	1967-69		Ave.	72.9	6.7	4.0	22	453	17	436					98	151	116,300	65,700
Sagamore Rd.	2	1969	2	Ave.	72.1	9.4	9.0											23,000	2,000
				Run 1	74.8	13.6	14.0					8.0						23,000	3,500
				Run 2	69.4	5.3	4.0	78	361	27	334	7.7	1.40	2.23		60	31	23,000	580
Houghton Rd.	3	1969	2	Ave.	66.8	6.2	3.8											26,500	5,250
				Run 1	65.5	6.9	5.0					7.5						32,000	9,600
				Run 2	68.2	5.5	2.6	39	410	11	399	7.9	.70	1.22		58	67	21,000	900

Table 21 (cont)

SAMPLE SOURCE	STATION	YEAR	NUMBER OF RUNS		TEMP. °F	DO mg/l	BOD5 mg/l	COD mg/l	TOTAL SOLIDS mg/l	SUSP. SOLIDS mg/l	DISS. SOLIDS mg/l	pH	NO_3 N mg/l	Kjel. N mg/l	TOTAL PHOS. mg/l	SO_4 mg/l	Cl mg/l	TOTAL COLIF. Per 100 ml	FECAL COLIF. Per 100 ml
CHIPPEWA CREEK																			
Riverview Rd.	1	1969	2	Ave.	73.2	7.4	5.5											53,000	2,000
				Run 1	77.0	8.0	7.0					8.1						5,000	0
				Run 2	69.3	6.7	4.0	39	384	3	381	7.4	.05	1.04	.23	103	21	101,000	4,000
Harris Rd.	2	1969	2	Ave.	74.5	8.7	32.3											98,000	12,900
				Run 1	80.6	12.2	9.0					8.1						17,000	9,000
				Run 2	68.4	5.2	55.5	172	454	29	425	7.6	.20	4.18		97	27	180,000	16,800
Avery Rd.	3	1969	2	Ave.	69.3	8.4	5.5											43,000	2,200
				Run 1	72.0	9.0	6.0					7.7						22,000	1,000
				Run 2	66.6	7.8	5.0	43	323	12	311	7.9	.85	.83		70	18	63,000	3,400
FURNACE RUN																			
Riverview Rd.	1	1967	9	Ave.	71.8	7.5	1.1	8	481	17	464		.31		.16	144	81	6,500	4,200
				Max.	79.7	9.5	3.5	18	506	76		8.1	.71		.30	170	87	25,000	21,000
				Min.	62.6	5.0	0	2	454	3		7.1	.00		.00	131	74	400	100
Riverview Rd.	1	1969	3	Ave.	73.1	9.0	1.2	16	473	14	459		.20	.30		128	50	15,600	500
				Max.	80.6	12.4	3.0	23	477	18	459	8.2	.25			136	50	25,000	810
				Min.	69.1	7.1	.1	8	470	11	459	7.8	.15			121	49	6,200	190
Riverview Rd.	1	1967-69		Ave.	72.1	7.9	1.1	10	479	16	463		.28			140	73	8,800	3,300
Brush Rd.	2	1969	2	Ave.	72.9	10.0	2.6											3,600	55
				Run 1	77.9	11.5	3.9					8.0						4,000	0
				Run 2	66.0	8.5	1.3	18	473	12	461	7.7	.15	.36		61	57	3,100	110
YELLOW CREEK																			
Riverview Rd.	1	1969	3	Ave.	69.8	9.1	2.7	28	479	131	348		.15	.29		45	25	69,500	4,200
				Max.	75.2	12.0	3.8	43	554	233	375	8.2		.53		89	26	197,000	6,400
				Min.	66.2	7.0	1.1	12	404	29	321	7.9		.06		1	24	5,500	290
MUD BROOK																			
Akron-Peninsula Rd.	1	1967	8	Ave.	65.0	6.3	5.9	41	564	16			1.50		.69	135	97	25,100	13,000
				Max.	73.4	9.3	27.0	148	847	58		8.2	3.17		1.90	196	200	90,000	65,600
				Min.	57.2	2.5	.8	10	421	3		6.9	.00		.31	40	34	3,400	1,100
Akron-Peninsula Rd.	1	1969	3	Ave.	65.5	8.3	2.6	32	448	21	426		.53	.75	.63	99	34	176,000	202,500
				Max.	69.8	8.4	2.7	48	448	29	433	8.1	.55	1.18		100	34	320,000	400,000
				Min.	60.8	8.0	2.5	16	447	14	419	7.9	.50	.33		98	34	32,000	5,000
Akron-Peninsula Rd.	1	1967-69		Ave.	65.1	6.8	5.0	39	532	17			1.23		.67	125	80	66,300	64,700
Seasons Rd.	2	1969	3	Ave.	63.2	2.5	11.0	45	432	28	404		.19	8.29	1.56	84	32	437,000	91,000
				Max.	66.2	5.4	13.1	71	438	39	409	7.8	.28	8.37		87	33	590,000	130,000
				Min.	59.0	0	7.8	20	426	17	399	7.1	.10	8.20		82	31	220,000	54,000
FISH CREEK																			
North River Rd.	1	1969	2	Ave.	64.4	8.3	2.7												
				Run 1	60.8	8.5	2.5	13	475			7.8	.30		.33			570,000	31,000
				Run 2	68.0	8.1	3.0					7.6							
SAND RUN																			
Riverview Rd.	1	1969	3	Ave.	66.2	8.6	2.2	32	662	223	439		.21	.24		140	16	32,000	1,400
				Max.	72.5	10.1	4.8	43	739	333	471	8.2	.40	.48		144	18	44,000	4,700
				Min.	61.9	7.15	.8	20	584	113	406	7.9	.03	.00		135	14	21,300	0
SLIPPER RUN																			
Riverview Rd.	1	1969	1		68.0	8.5	4.7					7.9						60,000	1,000
SPRING CREEK																			
Riverview Rd.	1	1969	1		77.0	11.4	5.0					8.0						9,000	0

*Source of Data: Three Rivers Watershed District, Cleveland, Ohio. 1970. A Plan for Water Quality Management in the Central Cuyahoga Basin. Prepared by Havens and Emerson Ltd., Consulting Engineers, Cleveland, Ohio.

from the Kent wastewater plant, and (6) oil, salts, soil sediments and debris from poorly managed urban and industrial land-altering projects. Within the City of Akron, considerable quantities of toxic industrial wastes enter the Cuyahoga River via the Little Cuyahoga River. Below Akron, wastewater from the Akron wastewater treatment facility combined with industrial wastes severely affects the Cuyahoga River for 15-20 miles nearly to the City of Cleveland. Within the City of Cleveland, domestic and industrial wastes drastically alter the normal physical and biological characteristics of the river.

Between Lake Rockwell and the City of Cleveland, nearly all of the Ohio Stream Water Quality Standards are violated, at least periodically. Dissolved oxygen levels remain relatively high because toxic pollutants inhibit oxygen consuming micro-organisms.

* Community Energetics Gross production/community respiration ratios probably approach one in most sections of the Upper Cuyahoga River above Lake Rockwell. River plant life is abundant and only moderate quantities of putrescent organic materials occur in most areas. The ratio of gross production to biomass probably is relatively high. Aquatic food chains are somewhat complex, weblike and relatively long.

Ecosystem metabolism in the middle and lower reaches of the Cuyahoga River is altered drastically by industrial and domestic effluents and by urban storm run-off. The ratio of gross production to community respiration would be difficult to estimate

* Definitions of ecosystem parameters begin on page 28.

because of the unpredictable effects of these wastes in the river.

Net community production probably is quite low despite an ample supply of plant nutrients. Toxic wastes, high turbidities, and poor substrates all inhibit the growth of aquatic plant life. Aquatic food chains are extremely short, simple and linear.

Community Structure The bottom-dwelling aquatic life in the upper Cuyahoga is dominated by intermediately pollution-tolerant organisms. These organisms usually account for 60% of the benthic community. The lack of suitable habitat limits the distribution and abundance of pollution-sensitive organisms in the upper river. Numerous dams and swamp areas considerably reduce the total area of erosional substrates most suitable for pollution-sensitive animals. There is a moderate variety of aquatic life, including game fish and pollution-sensitive minnows and darters.

In the middle and lower sections of the river, the bottom dwelling aquatic life is dominated by pollution-tolerant organisms. In most cases, these organisms account for over 90% of the benthic community. Both the variety and abundance of life are severely limited. Several species of pollution-tolerant fish survive in a few areas, but most of the region is devoid of a permanent fish population.

A summary of benthic invertebrate community-structure parameters for the Cuyahoga River is shown in Table 12. The number of species, two species diversity indexes, and the percentage of

pollution-sensitive, intermediate, and tolerant organisms collected from the Cuyahoga River are recorded. Fourteen stations were sampled. Only three stations (104, 120, 127) in the upper Cuyahoga River contained 25 or more species. Although the chemical water quality in the upper Cuyahoga appears to be satisfactory, extensive areas of depositional substrates caused by dams, low flow augmentation, and natural swamps restrict the variety of benthic invertebrates.

In the middle and lower Cuyahoga River, the number of species is reduced dramatically. This situation is reflected in both the Shannon diversity indexes and the Beck biotic index. Although the natural substrates should support 50 or more species, effluent from domestic wastewater treatment facilities and industrial wastes destroy large numbers of pollution-sensitive species.

Except for upper Cuyahoga stations 104 and 120, pollution-sensitive organisms accounted for less than 15 percent of the organisms at each station. Even at stations 104 and 120, pollution-sensitive organisms accounted for only 17.5 and 24 percent respectively. Because of the nature of natural substrates at most stations pollution-sensitive organisms should account for over 80 percent of the benthic invertebrates.

Intermediately pollution-tolerant chironomids and other fly larvae accounted for over 70 percent of the organisms collected at 10 of the 14 stations sampled. This included stations in both the upper and middle reaches of the Cuyahoga River.

Pollution-tolerant chironomids, sludgeworms or air-breathing snails accounted for over 75 percent of the invertebrates collected

at stations immediately below wastewater treatment facilities at Kent and Akron.

<u>Nutrient Cycling</u> Nutrient cycling in the upper Cuyahoga is well controlled in most areas. Inorganic nutrients such as phosphates and nitrates are utilized efficiently by the river plant life. Phytoplankton in Lake Rockwell is particularly effective in removing phosphates and nitrates.

In the middle and lower Cuyahoga River, nutrients are almost totally uncontrolled by the aquatic plants and animals. The concentration of phosphates and nitrates is excessive and these materials enter Lake Erie in great abundance. The presence of toxic wastes greatly restrict the variety and abundance of aquatic plants that normally control these nutrients.

b. <u>Baseline Condition for the Rocky River Basin</u>

Baseline conditions for the Rocky River Basin are shown in Table 10. Most of the Rocky River, both East and West branches, is badly polluted with poorly treated and untreated domestic wastes. Only a few kilometers of the headwater regions are relatively unpolluted. Extensive organic sludge deposits exist below water treatment plants and wastewater treatment facilities. Coliform bacteria exceed the State of Ohio Stream Water Quality Standards in nearly all areas. Dissolved oxygen levels decline to near zero in down stream regions during summer low-flow periods. Total dissolved solids exceed Ohio standards in most areas. Most lakes used for swimming require chlorination to meet bacterial standards.

Community Energetics Because of the extensive organic pollution in the Rocky River, P/R ratios probably average considerably less than one. Respiration rates of the micro-organisms occupying the vast quantities of organic sludges probably greatly exceeds the gross photosynthetic rate of the river flora. Because of the extensive sludge deposits, gross production to standing crop biomass ratios probably are extremely low. Aquatic food chains are linear and extremely short.

Community Structure The aquatic life in most regions is dominated by pollution-tolerant sludge worms and chironomids. These organisms usually account for more than 60% of the bottom-dwelling animals. The variety of aquatic organisms is very low, except for short sections of the headwaters region.

A summary of benthic invertebrate community-structure parameters for Rocky River is shown in Table 13. The number of species collected at each of 18 stations is recorded, as well as the widely used Beck biotic index of pollution (Beck, 1955). The natural substrates at most stations were suitable for 50 or more species of benthic invertebrates. Beck indexes should total at least 50 at each station. Examination of Table 13 indicates that no station approached these desirable values. Only two headwater stations contained more than 20 species. Eleven of eighteen stations contained ten or fewer species of invertebrates. Beck indexes followed a similar pattern. Only three headwater stations had indexes greater than 20. Eleven of eighteen stations had index

values less than 10.

Nutrient Cycling Nutrient cycling is poorly controlled in most of the Rocky River. Inorganic nutrients such as phosphates and nitrates are mostly extrabiotic and controlled by physical factors rather than biological organisms. The concentration of phosphates and nitrates is excessive and the nutrients are not completely utilized by the river flora. Excess nutrients empty into Lake Erie where they add to an already over-fertilized lake.

c. Baseline Conditions for the Chagrin River Basin

Baseline conditions for the Chagrin River Basin are shown in Table 11. Most sections of the Chagrin River contain water of relatively good to moderate quality. Short stretches below several wastewater treatment facilities contain sludge deposits and relatively low levels of dissolved oxygen. Within the Village of Chagrin Falls, mildly toxic materials enter the stream from storm sewers and a small industrial firm. Coliform bacteria usually exceed the State of Ohio Stream Water Quality Standards in most areas.

Community Energetics Gross production/community respiration (P/R) ratios probably approach one in most sections of the Chagrin River. River flora is abundant and organic sludge deposits less extensive than in either the Rocky or Cuyahoga Rivers. For this reason, the ratio of gross production to standing crop biomass is probably relatively high. Aquatic food chains in upstream areas

are relatively complex, weblike, and comparatively long. In downstream sections and areas immediately below wastewater treatment facilities, food chains are short, simple, and linear.

Community Structure A summary of benthic invertebrate community-structure parameters for the Chagrin River is shown in Table 14. Benthic invertebrates, because of their importance in aquatic food chains, usually provide a reliable and convenient indication of the conditions of other aquatic communities. The number of species, two species diversity indexes, and the percentage of pollution-sensitive intermediate, and tolerant organisms collected from the Chagrin River are recorded. Sixteen stations were sampled. Shannon diversity indexes (Wilhm and Dorris, 1968) and the percentages of pollution-sensitive, intermediate, and tolerant organisms (Mackenthun, 1969) were calculated for only 6 stations. Two headwater stations contained a relatively large number of species; 34 at Dines Road and 40 at U.S. Route 87. The number of species collected at the remaining stations, however, ranged from only 6 to 25. These stations should contain 50 or more species of benthic invertebrates. Beck indexes followed a similar pattern. Index values at headwater stations 49 and 51 were relatively high, indicating a normal diversity of benthic invertebrates. At the remaining stations, however, indexes were quite low indicating a greatly reduced diversity of aquatic life. A similar pattern of diversity was indicated by Shannon diversity indexes.

The greatest proportion of organisms collected at most stations were intermediately pollution-tolerant chironomids. Inorganic

silts and septic tank drainage covered large areas of the natural eroding substrates, thus destroying considerable habitat for pollution-sensitive organisms such as stoneflies and mayflies.

Cold water fish including trout and darters inhabit several headwater areas. The variety of organisms is moderate to large in most headwater regions, but considerably reduced in downstream areas.

Nutrient Cycling Nutrient cycling is moderately well controlled in most of the Chagrin River. Inorganic nutrients such as phosphates and nitrates are utilized to some extent by the river flora. Only moderate quantities of these plant nutrients enter Lake Erie.

2. Public Health Baseline Conditions

The search for baseline conditions in the public health area was conducted among the governmental and major private agencies in the region as well as at the state level. With the exception of the standard vital statistics, no agency has compiled an analysis of the current health problems or trends in the basin or any of its component parts. This deficiency has tended to inhibit our consideration of specific effects within the basin. However, there is adequate evidence of hygienic hazard, both potential and actual, in environmental and public health literature.

The health problems of wastewater management are inevitably related to the constituents transported and how they relate to the future use of that water. In terms of Lake Erie, as the receiving body of water for sewage residuals and as the source of drinking water for millions of residents of the basin, we are unable to avoid the conclusion that all straws are sipping out of the same septic tank. Although epidemics of water borne diseases such as typhoid, dysentary and cholera have been brought under control and are no longer statistically significant, water borne diseases still exist. The epidemic at Riverside, California in 1965 which affected 18,000 people, a 30% attack rate in Angola, New York due to a failure of the disinfection system of the water supply, and the 60% hepatitis attack rate which afflicted the Holy Cross football team in 1969, provide ample indication of the effect of inadequate control.

Recent studies by the U.S. Public Health Service report that millions of people in the United States drink water that contains

potentially hazardous amounts of chemical and bacteriological contamination. There is a steady increase in the number of new chemical contaminants, estimated as high as 500 per year. It is questionable, given the most optimistic interpretation, whether water systems can deliver adequate quantities of safe water under these circumstances. Recognizing the major importance of drinking water, consideration must also be given to the public health aspects of water based recreation. Reduction of recreational opportunity represents the most widespread consequence of water pollution. Bacterial levels have effectively closed the beaches of Lake Erie and new knowledge about the concentration of pollutants at the air-water interface presages new hazards for body contact sports at considerable distances from the shoreline.

By the year 2020, it is estimated that our national water requirements will exceed 1300 billion gallons each day. However, hydrologists believe that our total usable surface water supply from rainfall is only 700 billion gallons per day. Under these circumstances, the necessity for reuse of our surface water resources is obvious. But the waste products of our highly urbanized, technological society, pollute our water, persist in our environment and react, one with another, in complex and little understood ways, to affect the life cycles of plant, animal and human organisms.

Our water resources illustrate the interaction of all parts of the environment and also the recycling process that characterizes every resource of the biosphere. Everything that man injects into his environment - chemical, biological or physical - can ultimately

find its way into the earth's water, and these contaminants must be removed by nature or man before the water is drinkable. While previous concern has centered on bacterial contamination, chemical pollution of receiving waters poses even larger problems. Quantities of pesticides, organic chemicals and toxic metals are entering the waters and are not being removed by established water treatment methods. Their daily consumption presents a potential threat to people's health.

It must be recognized that the concentration of a specific substance in drinking water may represent only a small fraction of the total human intake of that substance. It is also essential to consider the intake from atmospheric exposure through the nose, eyes, lungs and digestive tract, foodstuffs, which in themselves may have served to concentrate specific pollutants; water and other beverages; and skin contact. Man's total intake of sodium, calcium, chloride and sulfates, for example, is generally far more dependent on his diet than on concentrations of these substances in drinking water.

An editorial in Science, 25 February 1972, states that community health is more directly dependent on disease prevention than on the availability and sophistication of resources for medical care. Great improvement in public health would be possible if we were able to understand and control the general environmental factors contributing to disease. The definition, explanation and control of the various determinants of disease requires an appreciation of the ecological systems of which they are a part. Environmental management holds forth the promise of new and more

effective means of disease prevention.

We can establish, despite the complicating factor of genetic variability, a working hypothesis that the difference in disease frequency between different populations is mainly the result of their different environmental experience. Therefore, the lowest observed risk of illness in any general population is a goal attainable in any other population. This falls somewhat short of the ideal of eradicating disease, but it is so far in advance of present reality that it should be acceptable as worthy of our efforts.

This approach is of specific and extreme importance in the managment of wastewater. Evidence is accumulating that minor constituents may have significant relationships to the chronic, long term, degenerative type diseases that are becoming major causes of illness and death as the bacterial diseases shrink before the antibiotics.

a. Public Water Supply Systems

The provision of adequate water has been and will continue to be one of the major elements governing residential and industrial development throughout the area. At the present rate of urbanization and industrialization, both the quantity and quality of water are important. Lake Erie, together with the principal rivers, reservoirs and inland lakes, assures a vast supply of surface water. Lake Erie, for example, supplies some 23 municipal water systems. About 2.7 billion gallons per day is withdrawn for residential, commercial, and industrial uses.

The real problem, however, does not lie in the quantity of raw water supply but in the increasing degree of pollution of the

principal water sources in the area. The condition of Lake Erie and its tributaries is an example. The quality of river water varies in different areas. Pollution related studies show that many of the streams are polluted heavily in some areas and are polluted to some extent over their entire length. The pollution of these tributaries has seriously affected the quality of Lake Erie water. Ground waters are also subject to pollution, from many sources.

There are a number of public and private water supply systems in the Three Rivers basin. These systems range in size from the water distribution system of the City of Cleveland, serving a total population of over 2,000,000, down to systems providing water to small neighborhoods or industrial complexes. Data on public water supply systems and the number of people they serve are shown in Table 22 .

In general, the larger public water supply systems along the Lake draw their supply of raw water form Lake Erie. The inland systems may be supplied from other sources such as rivers, inland lakes, reservoirs and wells. The majority of small inland water systems use ground water which, in many instances, is consumed without treatment.

Among the present public water supply systems, the largest is that of the City of Cleveland which distributes water to all of Cuyahoga County and parts of the adjacent counties of Lorain, Medina, Summit and Lake. The Cleveland Water Division serves a total of 75 municipalities, including the City of Cleveland, over an area of 560 square miles with an estimated total population of 2.0 million.

TABLE 22 Estimated Population Served By Public Water Supply Systems, 1969

County	Population Served	Total Estimated County Population	Percent of County Population Served
Cuyahoga	1,824,035	1,768,022	103.5[1]
Geauga	5,695	62,148	9.2
Lake	134,785	194,022	69.5
Lorain	207,300	264,713	78.2
Medina	30,870	80,324	38.5
Portage	53,190	118,240	45.0
Stark	253,421	369,315	68.5
Summit	457,400	569,513	80.5
TOTAL	2,966,736	3,426,197	86.6 av.

Source: State of Ohio, Dept. of Health, Division of Engineering Water Supply Unit, Lake Erie Basin Inventory of Public Water Supplies by County, January, 1969.

Northeast and Southeast Ohio Water Development Plans Burgess and Nipple, Ltd., Principal Consultant, Existing Public Water Supply Systems (working papers).

State of Ohio, Development Department, Economic Research Division, Population Estimates for Ohio, January, 1969.

[1]The water department of the City of Cleveland also serves the population of parts of four adjacent counties.

In 1969, the total average daily consumption in the system was 363 million gallons, with a maximum consumption of 545 million gallons. Today, a maximum of 615 million gallons of water can be drawn daily from the Lake through four intakes. In 1969, the annual water consumption was about 132 billion gallons.

The fact that the public water availability and supply is an important factor in urban development is manifested in the number of water studies which have been carried out or are under way. The Ohio Water Commission, Department of Natural Resources, has completed a comprehensive water development plan for Northwest Ohio, one of the five regions into which the state was divided. The other four regions are the Northeast, Southeast, Southwest and Central. Similar studies for the Northeast and Southeast areas are currently under way. The purpose of these studies is to provide a comprehensive plan for the development of water resources that will give maximum support to the growth and development of the individual regions and the State of Ohio.

The City of Cleveland, Department of Public Utilities, has also initiated a major study which is presently under way and which will provide the City with a physical and financial expansion plan for its water supply and distribution system phased through 1990 and 2010. The proposals of this study will be incorporated into the Northeast Ohio Water Plan study initiated by the Ohio Water Commission of the Department of Natural Resources.

Future development will require the coordinated expansion of present water supply systems and the proper utilization of both surface and ground water sources. The abundance of natural water

supplies is an important asset to the area and can contribute in large measure to its future economic and industrial development. Proper measures on a region wide basis must be taken, however, in order to prevent the threat of further deterioration of the quality of water resources.

b. Public Sanitary Sewer Systems

The Cleveland sewage disposal system serves a broad area. In 1968 it served an estimated 1,326,251 persons in Cleveland and 21 other municipalities. Other major municipal plants serving outside communities are those of Akron, Canton, Lorain, Euclid, and Erie, Pennsylvania. These five systems together served an estimated population of 918,800 in 1969. Another major public system in the area of Northeast Ohio is that of Youngstown which serves 164,741 people in its area.

The estimated population having access to public sewage treatment works in the Three Rivers area, by County, is shown in Table 23. The public sewerage systems in the district served about 75% of its population in 1968.

Many counties and municipalities have plans at present for the improvement and expansion of their sanitary sewer systems to meet future needs in wastewater disposal facilities. Plans have been drawn for regional interceptors for Cuyahoga County which would provide water pollution control facilities to an area extending from west of the Rocky River to essentially the Chagrin River, and from Lake Erie south to the drainage division between Lake Erie and the Ohio River watershed. The boundaries of the area to be served by the proposed system coincide approximately with the boundaries

TABLE 23. Estimated Population Having Access to Public Sewage Treatment Works, 1968

County	Population Served	Total Estimated County Population	Percent of County Population Served
Cuyahoga	1,649,640	1,774,089	93.3%
Geauga	6,618	61,392	10.7
Lake	63,420	198,841	31.8
Lorain	188,777	264,539	71.5
Medina	28,191	80,930	34.8
Portage	56,010	113,341	49.5
Stark	179,877	370,618	48.5
Summit	401,468	569,953	70.6
TOTAL	2,574,001	3,434,243	74.9 av.

Source: State of Ohio, Ohio Department of Health, Division of Engineering, Municipal Sewage Treatment Works in Ohio, January, 1970.

State of Ohio, Development Department, Economic Research Division, Population Estimates for Ohio, January, 1968.

of the Cleveland water system

In spite of all the wastewater disposal studies which have been completed or are under way, the problem of water pollution still remains virtually the same and probably will continue until regionally coordinated plans are implemented to effectively control the pollution from the entire watershed

3. Esthetic - Recreational Characteristics

Although esthetic descriptions tend to be subjectively relative to individual opinions, the Three River Watershed area may generally be regarded as esthetically deficient in its present image. The rolling topography of the area with its extensive water resources, offers esthetic potential for outdoor recreational activities and general landscape amenities, but such potential is inhibited in many areas of the watershed by the dominating influence of the highly industrialized Cleveland-Akron complex, and the associated problems of urban blight, congestion, and sprawling growth patterns.

In describing the study area's esthetic and recreational conditions, a general framework is indicated for guidance. Water related recreation covers a wide range of activities, of which two major water-use types may be generalized: use of water as a medium on which or in which the recreational participants engage, and the function of water as a scenic value, where the value of water is an esthetic resource contributing to the visual quality of the landscape. The range of recreational activities occurring under these

general water uses are:

Water-Based	Water-Enhanced
Swimming	Camping
Fishing	Picnicking
Boating	Sightseeing
Canoeing	Nature Walks
Sailing	Hiking
Water-skiing	Hunting
	Driving for Pleasure

Although perceptions of the person in the role of recreation user may be mutually exclusive of his perceptions as an industrialist, the perspectives may conflict.

a. Trends of Increasing Demand

In terms of the demand for recreational opportunities, the Northeast Ohio population's participation in water-oriented recreation is typical of national trends, which manifest the American preference to utilize increased leisure time in outdoor recreational activity. The 1962 Study of the U.S. Outdoor Recreation Resources Review Commission (ORRRCA) projected a dramatic increase in outdoor recreation, including all water-related activities. However, the quantity of water for future recreational use is in doubtful supply considering the inhibition of existing polluted water conditions.

Table 24 presents the participation rates of June-August 1960 for various water-related recreational activities of the U.S. North Central regional population, which may be considered indicative of the Three Rivers Watershed. Significant portions of the total population participated in all activities, with race and income class as major indicators of differential rates among classes. Over the brief span from 1960 to 1965, changes show a trend towards increased

Table 24 Participation of Persons 12 Years and Over, Days of Activity per Person Participating During July August, 1960, U.S. Water Oriented Recreation

Socio-Economic Characteristics	ACTIVE-WATER BASED						PASSIVE-WATER-ENHANCED					
	Swimming		Fishing		Boating		Picnicking		Driving for Pleasure		Nature Walks	
	% Part.	Days/ Person	% Part	Days/ Person	% Part	Days/ Person	% Part.	Days/ Person	% Part.	Days/ Person	% Part.	Days/ Person
ALL CLASSES	42	4.63	33	2.05	27	1.48	58	2.34	58	8.02	15	.60
Family Income												
Less than $1500	14	.58	24	1.08	5	.12	28	.94	33	2.67	3	.30
$1500-2999	27	2.01	25	1.57	8	.70	55	1.63	48	4.66	11	.32
$3000-4999	27	3.69	36	2.62	20	.78	59	1.88	59	8.76	9	.30
$4500-5999	49	4.42	42	2.13	30	1.43	66	2.62	63	6.90	20	.82
$6000-7999	48	5.30	33	2.18	35	2.56	61	2.84	67	11.52	19	.68
$8000-9999	60	7.03	31	2.43	34	2.25	64	3.11	58	10.24	27	1.00
$10,000-14,999	57	8.06	40	1.79	50	2.50	64	3.18	69	11.22	19	.60
$15,000 +	61	10.18	21	.79	39	1.45	48	2.44	59	7.53	20	.46
Race												
White	42	4.81	33	2.10	28	1.56	58	2.36	58	8.08	16	.62
Non-White	33	2.20	31	1.44	7	.43	62	2.08	53	7.26	10	.27
Residence												
In SMSA	47	5.12	32	1.97	30	1.67	59	2.69	63	8.93	19	.75
Not in SMSA	33	3.84	34	2.19	21	1.18	56	1.78	43	6.54	10	.36

Source: National Recreation Survey, Abbot L. Ferris, ORRCA Study Report No. 19, Wash. D.C., 1962.

participation in all water-related recreational activities. Non-participation rates show a 5% rise from 1960 to 1965 in the "lack of supply & distance" factor (See Tables 25 and 26.) Thus, it appears that adequate development of water-related outdoor recreation opportunities is not keeping pace with the increasing demands of the American public.

b. Current Supply Deficiencies

The existing conditions in the Three Rivers Watershed area indicate a valid basis for concern with recreational potentials affected by alternate wastewater management systems. In general, the area is endowed with a wide variety of water resources. However, the quality of water and adjacent landscapes for recreation has become increasingly poorer, and the impact of urban-industrial encroachment on existing open space areas has inhibited recreational development.

The major environmental influence of the Cleveland area is the presence of Lake Erie. Its major recreational resource is its extensive metropolitan park system, which encircles the city along and between its major river valleys. Lake Erie is central to the entire metropolitan region, yet most of the region's population is cut off from the Lake through commerical and private development. In the City of Cleveland, the port occupies the principal water front shoreline. Away from the port district, much of the shore line and lake front is occupied by commerical and residential land uses. As one travels further from the center of the city along

Table 25 Outdoor Recreation Activity Days Per Person (Persons 12 yrs. of age and over) U.S., Summer 1960 and Summer 1965

ACTIVITY	DAYS PER PERSON 1960	1965
Passive		
Driving for pleasure	6.68	6.65
Picnics	2.14	3.21
Sightseeing	2.20	3.20
Walking for pleasure	4.34	7.34
Nature walks	0.75	1.77
Water Activities		
Fishing	1.99	2.26
Canoeing	0.07	0.14
Sailing	0.05	0.16
Other boating	1.22	1.56
Waterskiing	0.30	0.42
Swimming	5.15	6.84

Source: 1960, U.S. National Recreation Survey; 1965 figures, Bureau of Outdoor Recreation, U.S. Dept. of the Interior, as reported in Abbot L. Ferris, "The *Social and Personality Correlates of Outdoor Recreation*."

Table 26 Changes in Reasons for Not Participating in Outdoor Recreation, U.S. 1960, 1965.

REASON	1960 %	1965 %	CHANGE %
Lack of time	25	29	4
Lack of supply, or crowdedness, or distance from home	17	22	5
Lack of skill, age, health, fear	21	19	-2
Lack of money	12	12	0
Lack of equipment	17	10	-7
Other	8	8	0
Total	100	100	

Source: Ibid.

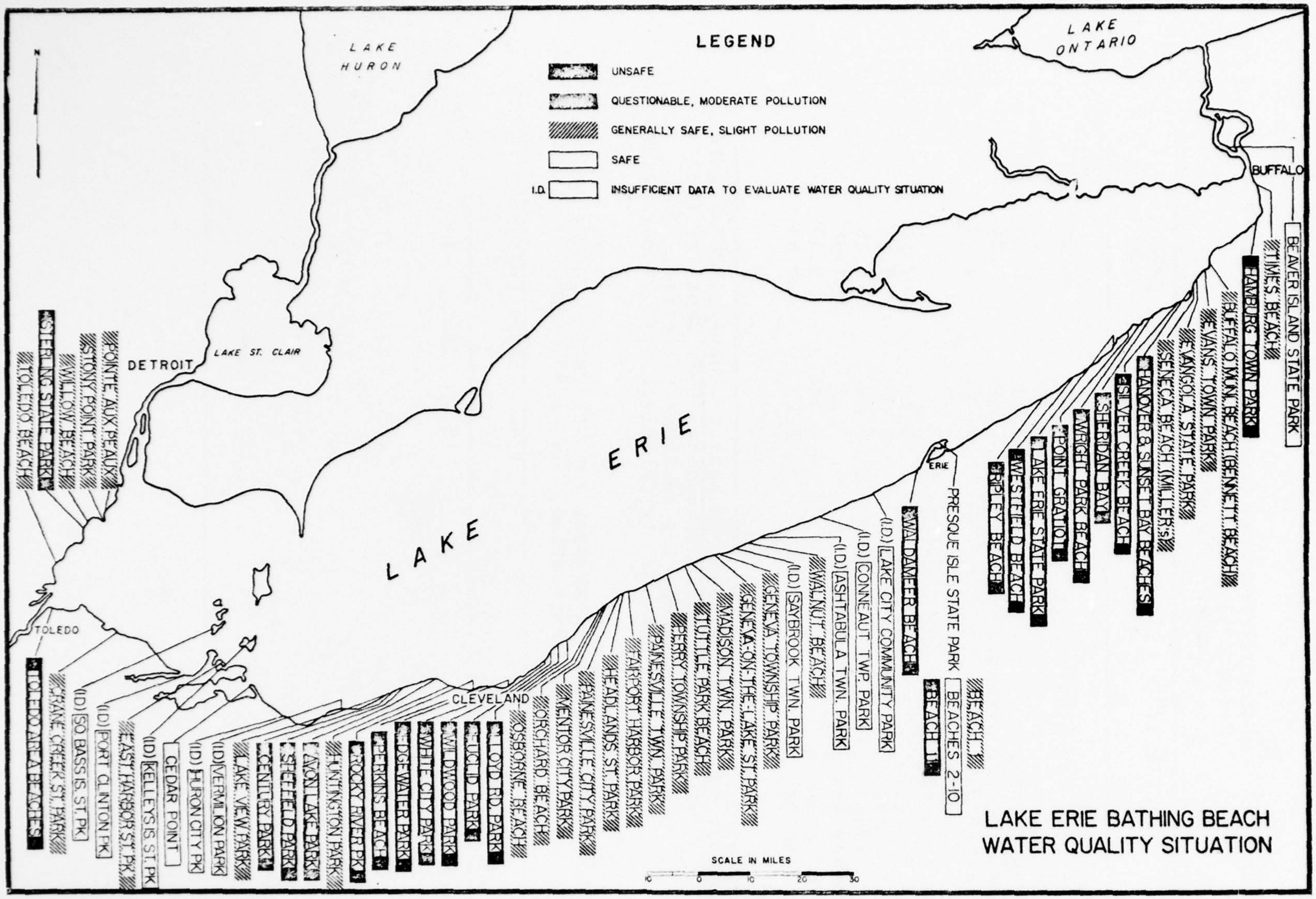


Figure 2: Lake Erie Bathing Beach Water Quality, June 1968 (FWPCA - U.S. Dept. of Interior)

the lake, private suburban developments and large estates successfully deny access to the lake, for much of the region's population Little of the lake front area is developed for recreational activities for which it is suited, and much of the area is in private and exclusive development. Those shoreline areas which had been used as bathing beaches have become ecologically and hygienically impaired Raw sewage discharges have caused levels of bacterial contamination which inhibit body contact activities, and trash, debris, oil and other noxious inputs have degraded the general appearance of the shoreline, as well as caused odor problems.

The nature of the lakeshore development effectively denies access to the amenities of the lake to the inhabitants of the inner city of Cleveland. These same residents are also at too Additional problems which constrain effective water-based recreation development for the region result from a similar degree of disjointedness between water management agencies of the State and the cities.

In general, the Three Rivers District is characterized by congestion and inadequate recreational land development which, it should be noted, is further aggravated by air pollution. The Cleveland-Akron corridor, which is the main axis of urbanizaiton within the district, has a considerable deficit in recreational land, as does the Lake and Lorain County areas. On the other hand, less densely populated counties to the southeast, south and southwest of Cleveland have a surplus.

c. Future Demand/Supply Potential

The Ohio Department of Natural Resources recently conducted a state-wide survey of outdoor recreation for the purpose of determining for each county and region the demand/supply and future needs for each of Ohio's most prevalent recreational activities: boating, swimming, hiking, camping, fishing, hunting, outdoor games and sports, picnicking and pleasure driving.

It has been estimated that Cuyahoga County needs an additional 151,000 acres of recreational development if its population is to enjoy adequate outdoor recreation within reach of the county. At least a third of that amount is associated with water-based recreation. The Akron metropolitan area, i.e., Summit County, needs an additonal 35,000 to 40,000 acres of recreational land if recreational facilities are to be reasonably accessible to its residents. Furthermore, the recreational potential of the less densely developed great a distance from the major metropolitan park development (the emerald necklace), which is south of the City of Cleveland and extends along portions of the Rocky River and Chagrin River basins. The lower Cuyahoga River flows through the downtown area of the City of Cleveland. However, the river is the epitome of industrial pollution, commercial land usage, and overall urban decay. The nature of the lake front development, the location of the metropolitan park system, and the "open sewer" nature of the lower Cuyahoga

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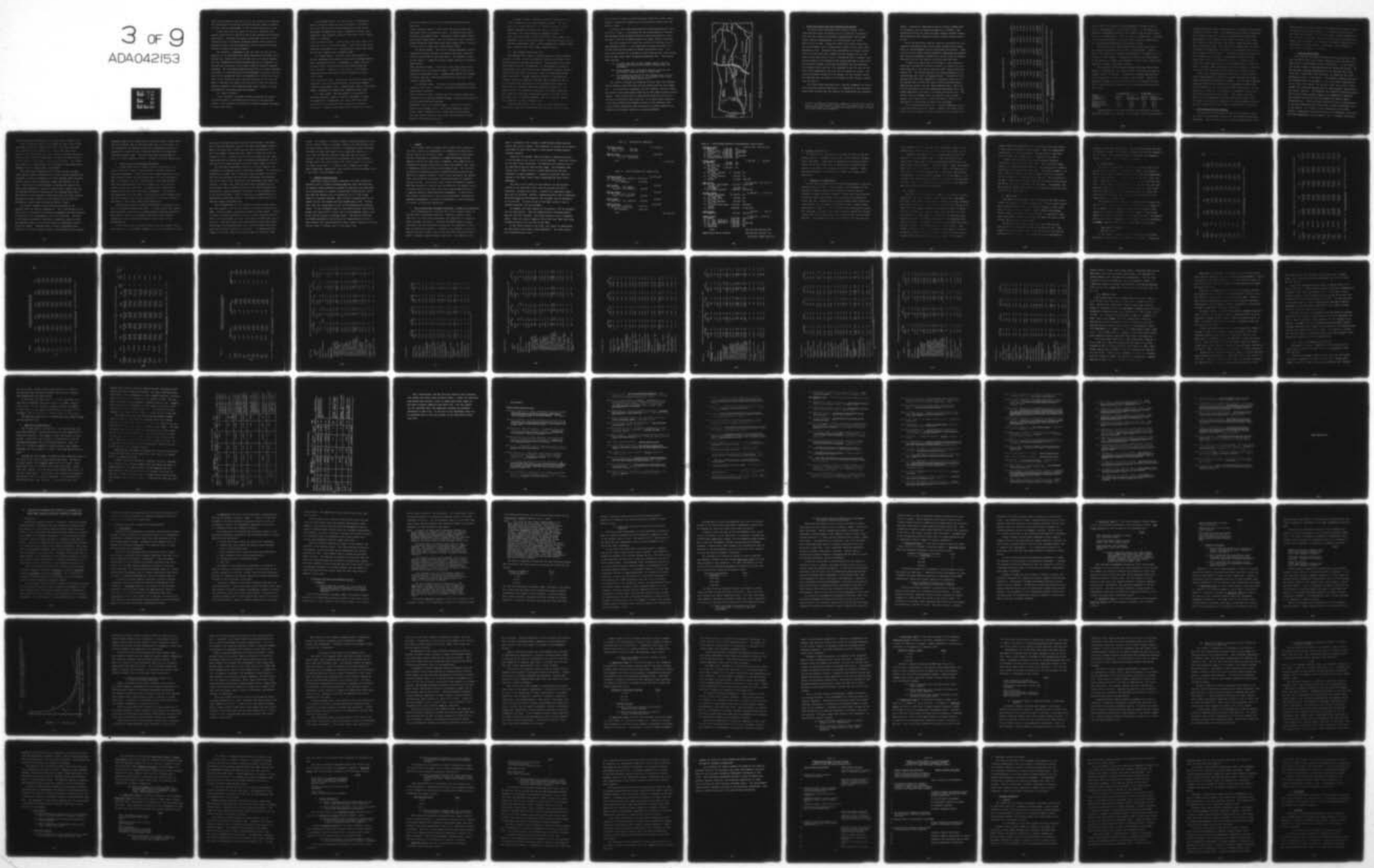

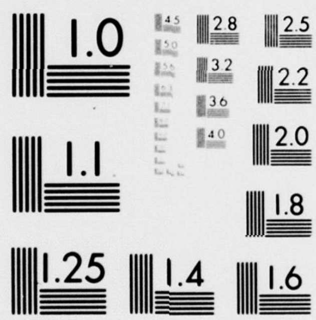

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

mean that residents of the central city are separated from meaningful interaction with the major recreational and community effects of water resource development in the Cleveland metropolitan area.

Further away from the center of the city, residents have greater access both to Lake Erie and to the sprawling metropolitan park system. Therefore, the water recreational resources of the Cleveland area, as presently developed benefit those population groups the least, who sociologically, have the greatest need and the most to gain from their presence.

The problem is compounded by the fact that not only do the majority of the developed water based recreation facilities lie in regions well outside the city and even some of its major suburbs, but that fragmentation between metropolitan and city agencies in the park and recreation field further inhibits effective regional planning. The Cleveland Metropolitan Park District cannot optimally coordinate its land acquisition and development activities with the needs of the population within the boundaries of the City of Cleveland itself--despite the fact that the residents of the city are taxed to maintain and support the activities of the Park District. counties adjacent to the Cleveland-Akron urban corridor is being threatened by increasing urban encroachment.

(1) County Profiles

A brief inventory of general esthetic profiles and outdoor recreation supply is outlined below for each of the watershed counties, with potentials indicated for balancing demand and supply to meet future needs.

(a) Cuyahoga County: The entire area is becoming completely urbanized, with substantial portions of available open space held by the Cleveland Metropolitan Park System. Topography throughout the county is generally rolling, with rugged and steep features along the three major rivers (Rocky, Chagrin & Cuyahoga).

Total recreation space: 27,188 acres (9.3% total county area)
Land/Water ratio of recreation space: 26,975/213 acres-(99/1)
Potential development sites: Cuyahoga River Valley, Ohio Canal Restoration, Chagrin River, Chippewa Creek.

(b) Geauga County: The area on the whole exhibits a diverse landscape with extensive tree cover including numerous areas exceeding 500 acres. Topography is rugged, with significant relief in the western section along stream and river corridors. Relative to the total N.E. Ohio Region, Geauga possesses a basically natural atmosphere of great scenic value.

Total recreation space: 21,918 acres (8.4% total county area).
Land/Water ratio of recreation space: 19,287/2,631-(88/12).
Potential development sites: Parkman Gorge, Silver Creek-Ansell's Ledges, Cuyahoga River Marsh Area, Punderson State Park.

(c) Lake County: The area exhibits a diversity of landscape patterns--south of I-90 the topography is steep and rugged with considerable tree cover, while the north presents flat to rolling features, generally lacking in tree cover. Extensive salt deposits are found in the county,

and major urbanization occurs in the western portion along Lake Erie.

Total recreation space: 12,393 acres (9% total county area).

Land/Water ratio of recreation space: 13,293/100 acres-(99/1)

Potential development sites: Grand River Valley, Mentor Marsh, East Branch Chagrin River (site of Penitentiary Gulch adjacent to Holden Arboretum, Lake Shore Beach Park, Chagrin River (location of Kitts Gully, a gorge with unique native flora).

(d) Medina County: The flat to rolling topography exhibits significant natural features in land and tree cover along the west and north forks of the Rocky River. The Northeast corner of the county is rugged and densely wooded (location of Hinckley Reservation).

Total recreation space: 9,340 acres (3.4% total county area).

Land/Water ratio of recreation space: 8,587/753 acres-(92.8).

Potential development sites: Chippewa Lake, Spruce Run (unique biological habitat), Lake Medina-Rocky River (reservoir with adjacent wooded land).

(e) Portage County: The area's rolling topography exhibits extensive tree cover; a number of reservoirs provide water-based recreational resources.

Total recreation space: 48,902 acres (15.1% total county area) (Includes the 21,422-acre Ravenna Arsenal, restricted recreational use for controlled deer hunting).

Land/Water ratio of recreation space: 41,397/7,505 (85/15).

Potential development sites: West Branch Mahoning, Eagle & Silver Creeks, Breakneck Creek, Dollar Lake and Streetsboro Bog, West Branch Reservoir State Park, Berlin Reservoir, Lake Rockwell and Mogodore Reservoir.

(f) Summit County: The area is heavily urbanized to the north, dominated by the Akron-Barberton complex. The Cuyahoga River-Furnace Run portion is the major natural resource Rugged topography with dense tree cover is present; the Tuscarawas River runs through the Southwest corner.
Total recreation space: 21,651 acres (8.1% total county area)
Land/Water ratio of recreation space: 17,631/3,930 acres (82/18)
Potential development sites: Upper Cuyahoga River Valley, Singer Lake, Cranberry Bog, "532" Swamp, Knight Property.

(2) The Cuyahoga Valley Park Plan

The Cuyahoga River Valley, situated along the Akron-Cleveland corridor, provides a major recreational resource accessible to the densely populated metropolitan complex. Preservation of the Valley from urban-industrial encroachment, for development as a natural recreational area, motivated the Ohio Department of Natural Resources' Study in the mid-1960's to develop a plan for realization of the area's potential. Through a detailed analysis of the physical, economic and social aspects of the land and its potential use, it was concluded that utilization of the Cuyahoga River Valley for open space and recreation meets the requisite criteria of: (1) large in area, (2) scenically attractive, (3) easily accessible, (4) suitable for multiple recreational purposes, (5) NOT suitable for other types of urban development, and (6) relatively inexpensive comparable to other regional sites.

Following publication of the study, the Akron Metropolitan Park District and the Cleveland Metropolitan Park District joined

in an effort to create a 20,000-acre park within the valley region. Figure 3 presents the location of the area and its many scenic and historic sites.

In April, 1971, Ohio Representative Seiberling proposed a bill to the U.S. House "...to provide for the establishment of the Ohio and Cuyahoga Valley National Historical Park and Recreation Area;" currently, the bill in pending before the House Interior Committee.

The Park proposal is a positive reaction to President Nixon's environmental policy, "...to bring parks to where the people are so that everyone has access to nearby recreational areas." The basic plan provides for a network of three separate but inter-related park and open space areas in populous Northeast Ohio. The network would include:

(a) A 28,000-acre park in the Cuyahoga Valley along the Cuyahoga River and old Ohio Canal, between Akron and Cleveland;

(b) Establishment of a recreation corridor along the old Ohio Canal, extending south of Akron; and

(c) Preservation of portions of the Cuyahoga River Stretching upstream from Akron, as a recreation river within the "Wild and Scenic Rivers Act."

The overall rationale in proposing the Ohio Canal and Cuyahoga Valley National Historical Park and Recreation Area has been summed as: "...to preserve for ourselves, and our children, the most scenic and historic open green space remaining in this highly industrialized region." With 10,000 acres of land already owned by the Akron or Cleveland Metropolitan Park Districts, or by quasi-public agencies, it has been proposed that federal control of the remaining land could feasibly progress by the utilization of scenic easements and retention of occupancy rights by existing landowners.

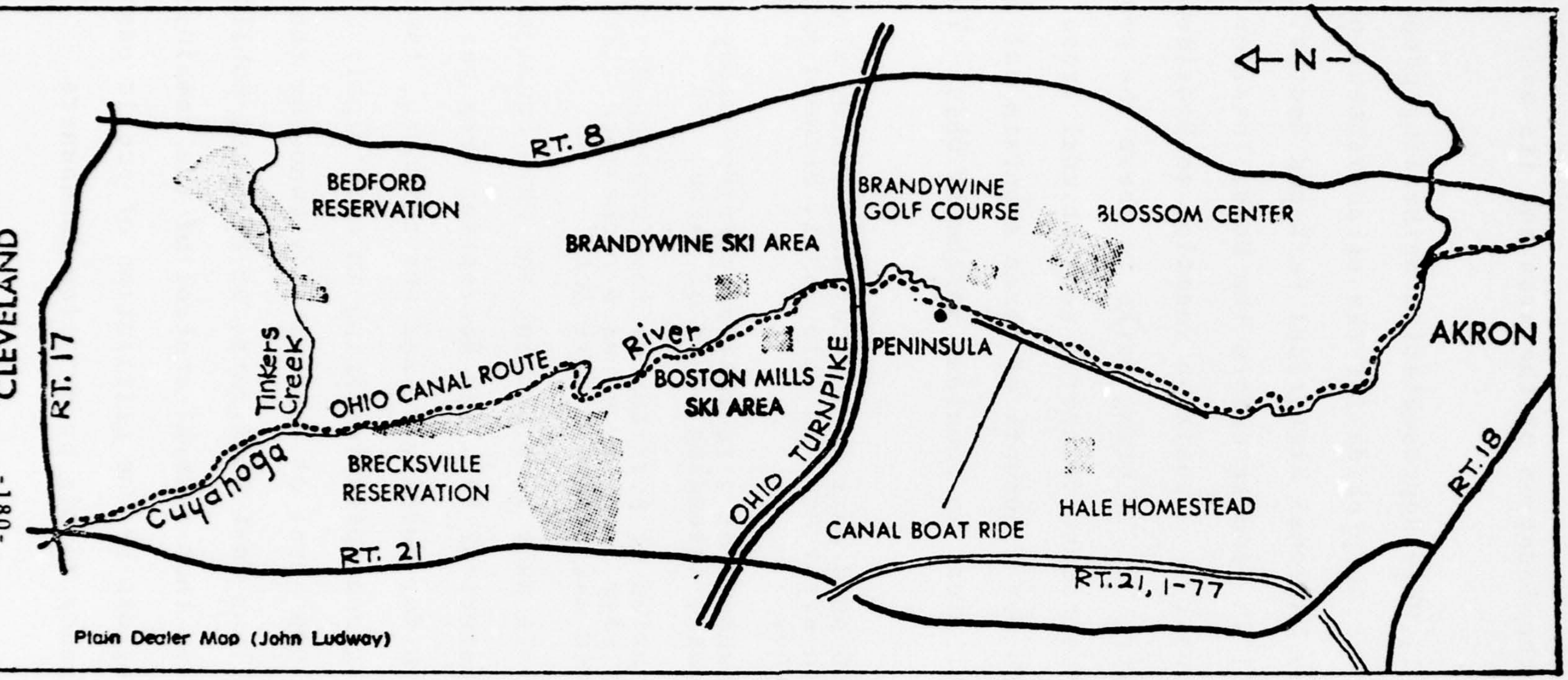

Figure 3. Cuyahoga River Valley between Cleveland and Akron - Site of the Proposed Ohio and Cuyahoga Valley National Historical Park and Recreation Area.

4. Social Well-Being (See also Esthetics-Recreation)

The Three Rivers Watershed falls within a larger, Cleveland-oriented region consisting of the 30 counties of Northeast Ohio and five counties of Northwest Pennsylvania.* This larger region contains approximately 5.6 million people on 17,000 square miles of land. During the 1950's this larger region had one of the higher rates of population increase in the Great Lakes megalopolis area. Northeast Ohio experienced an average increase of 21.5% during 1950-1960, compared to the average rate for the larger Great Lakes area of 15.9%. During the 1960's, however, population growth in the Northeast Ohio region declined to about half the national average, indicating considerable net out-migration. The Northeast Ohio rate was 7.5%, compared to an 8.8% rate for the Great Lakes megalopolis and 13.8% for the nation as a whole. The population growth during the last decade, for the counties within the Watershed was the lowest of any decade in this century, excepting the 1930's.

The Three Rivers Watershed area, from the standpoint of social well-being and economic opportunity, is dominated by the Cleveland-Akron urban corridor and its patterns of urbanization and suburbani-

* From the standpoint of marketing, communications and other economic factors, the Cleveland area is part of a far larger system than the Three Rivers Basin. The available data generally relates to larger areas than these seven counties.

zation. Cleveland is identified as one of 50 major trading areas in the nation, with its market extending to 21 counties. Both Cleveland and Akron are classed as major regional business centers, while Cleveland ranks among the 10 major national business centers as well.

While the Three Rivers area as a whole is relatively well off compared to peripheral areas of the larger Northeast Ohio region, there are varying degrees of well-being within the district. Rates of total and per capita income, population, employment and unemployment have been presented in Tables 31-35 in the section on Economic Characteristics for the counties within the watershed areas.

Of particular significance in Cleveland, is the comparative lower rate of growth over the past 25 years, in indices of social well-being such as per capita income and family income within the central city. The central area has been losing population at an accelerating rate to the surrounding suburbs. A decline of 14.3% occurred from 1960-1970, compared to a suburban increase of 27.1%. The suburbs have attracted the higher income population brackets, depriving the central city of a much needed tax base. While the City of Cleveland is still the predominant employment source, the growth supported by this base is occurring outside the city. The eastern strip of Cuyahoga County and adjacent areas of Lake, Geauga, and Portage Counties contain the greatest relative concentrations of high income and educational attainment.

The Cleveland metropolitan area is deteriorating over time in a consistent and predictable fashion. However, the center of the city is deteriorating most rapidly and has the most critical area

TABLE 27 Population Growth by County, 1900-1970

County	1900	1910	1920	1930	1940	1950	1960	1970
Cuyahoga	439,120	637,425	943,495	1,201,455	1,217,250	1,389,532	1,647,895	1,721,300
Geauga	14,744	14,670	15,036	15,414	19,430	26,646	47,573	62,977
Lake	21,680	22,927	28,677	41,674	50,020	75,979	148,700	197,200
Lorain	54,857	76,037	90,612	109,206	112,390	148,162	217,500	256,843
Medina	21,958	23,598	26,067	29,677	33,034	40,417	65,315	82,717
Portage	29,246	30,307	36,269	42,682	46,660	64,954	91,798	125,868
Stark	94,747	122,987	177,218	221,784	234,887	283,194	340,345	372,210
Summit	71,715	108,253	286,065	344,131	339,405	410,032	513,569	553,371
TOTAL	748,067	1,036,294	1,603,439	2,006,023	2,053,076	2,437,916	3,072,695	3,372,486

Source: 1. 1900-1960 figures: Statistical Abstract of Ohio, 1969, Economic Research Division, Development Department, State of Ohio.

2. 1970 figures: 1970 Census of Population, Final Population Counts, Ohio PC(VI)-37 Bureau of the Census, U.S. Department of Commerce.

an area that has increased from approximately 10 square miles in 1960 to approximately 17 square miles in 1970. At the same time, generally unfavorable conditions grew from an area of some 33 square miles to 40 square miles. Three corridors of urbanization, radiating from Cleveland toward Elyria-Lorain, Akron, and Erie respectively, are experiencing progressive deterioration as well.

The central city of Akron demonstrates similar deterioration and population decline, with growth of suburban areas. During 1960-70 the central city population declined by 5.2% against a 28.2% increase in the suburbs. Although major efforts for redevelopment of the central city have been attempted in recent years, deteriorated conditions remain in the heart of Akron.

Out-migration from Cleveland-Cuyahoga County and Akron-Summit County is spilling over into Medina County on the west and Lake and Geauga Counties on the east. Furthermore, economic opportunities are following the residential flight to the suburbs. Industrial employment changes for the period 1958-1967 in Cleveland and Akron SMSA's central cities relative to their outlying areas substantiate this trend:

Percent Change from 1958-1967	Cleveland SMSA		Akron SMSA	
	Central City	Outside Central City	Central City	Outside Central City
Manufacturing	-5.3	45.9	13.6	15.0
Retail trade	-20.3	89.5	2.3	61.5
Wholesale trade	-12.4	171.9	17.7	92.9
Services	3.2	135.2	15.0	76.2

Planning bodies within the watershed area uniformly anticipate that these trends will continue. For instance, the Cleveland Regional

Planning Commission sees no indication of a reversal of this decline during the period to 1990. The Commission notes that out-migration from Cuyahoga County has increased considerably in recent years and apparently will remain at high levels for some time to come. This trend will hold for most old, heavily industrialized, urban areas in northeast Ohio. The Commission estimates that the City of Cleveland will experience a 33% decline in population by 1990 to a base of around 500,000 persons. The Commission also estimates that the suburban areas will grow in population by almost the same amount that the City of Cleveland will lose. In other words, a relatively stable population will be maintained for the county as a whole. Cuyahoga County population will stay at about 1.7 million, rising by little more than 20,000 persons in the next 18 years.

While such extended population stability is not forecast by other planning agencies, population growth estimates are being reduced considerably from earlier estimates. The Tri-County Regional Planning Commission has reduced thier projections in their most recent forecast by 32% from previous (1964) projections. The difference is a result of a re-evaluation of migration trends and of the observed decline in birth rates. Their report indicates delays in the development of the non-metropolitan areas of the Tri-County area due to an incapability to provide sewers and water and the reduced growth of the older, central cities in the area.

5. Institutional-Political Factors

The operations of the public sector are, no doubt, a short-term factor in evaluating proposals for new methods of wastewater management. Once the political system has determined upon a parti-

cular course of action, political and administrative routines adjust to the new policy rather quickly. To say that political factors are short-term, however, is not to deny their crucial significance. The blessings of stability, which are obvious in the carrying out of administrative routines, are frequently formidable obstacles to the displacement of older routines. Therefore, some assessment of institutional parameters is in order.

a. Planning Capabilities

The structures for public planning in the study area are important because of their role in goal setting for both the area as a whole and its constituent political subdivisions. In this regard, the current status of planning presents an interesting anomaly. On the one hand, planning organizations at the municipal and county level have a relatively solid tradition, in comparison with other metropolitan areas in the country. The Regional Planning Commission of Cuyahoga County, for example, is one of the older organizations of its type in the nation. On the other hand, the area as a whole suffers from area-wide planning that is underfinanced, understaffed, and weakly supported. The Northeast Ohio Areawide Coordinating Agency, which covers seven counties, began in an atmosphere of suspicion and acrimony between the local governments and federal agency representatives. NOACA has never enjoyed the type of administrative or official leadership that would build a stable constituency within the region. As a result, it has suffered one crisis after another, culminating in decertification by the Department of Housing and Urban Development in the summer of 1971. Although recertifica-

tion was achieved in February, 1972, NOACA seems as weak as ever

From a technical point of view, NOACA has done little toward preparing the necessary metropolitan water and sewer plans that are a prerequisite for federal aid Some of the constituent agencies, most notably the Tri-County Regional Planning Commission, have proceeded toward the development of water and sewer policies for the counties within their separate jurisdictions But NOACA's participation has been minimal, and the output so far hardly seems enough to satisfy federal grant requirements.

The Three Rivers Watershed District has provided the major thrust toward regional consideration of water resource problems and solutions, as well as leadership for those regional water pollution control systems that are gradually coming into operation in the area. The District was instrumental in getting the scope of the Corps study broadened to cover the whole District rather than just the metropolitan area of Cleveland and the Cuyahoga River basin. The District is the principal coordination point for water resource planning of Federal, State and local agencies and its work has provided key inputs into the planning efforts of each.

The endemic weakness of goal-setting activities at the regional level has had two consequences. One is the absence of any public policy objectives for wastewater management that have received the approval of all governments within the study area. The other is the relative absence of widespread recognition, among citizens and interest groups, of the precise nature of wastewater problems within the region. Although bumper stickers proclaiming "Save Lake Erie!" are seen in great profusion, the absence of any regional

spokesman leads one to believe that no one quite knows in what terms Lake Erie suffers, and in what terms Lake Erie is to be saved. In all probability, the popular perception of wastewater pollution is composed of a series of small localized problems of drainage and overflowing septic tanks. The fact that these problems may be a part of a larger regional problem is probably not widely appreciated.

b. <u>Flexibility of Institutional Structures</u>

As in many other areas of public service responsiblity, the Constitution and statutes of Ohio provide a flexible system for wastewater management. Municipalities may conduct wastewater treatment through statutes and the general powers of local self-government, as granted in the Ohio Constitution. Those municipalities that have adopted charters may also organize for this function without significant constraint. In recent years, counties have become heavily involved in wastewater management. All counties are authorized to set up county sewer districts, and to employ county sanitary engineers, who are not responsible to the county engineer, but rather to the county commissioners themselves.

The Ohio legislature is usually very liberal in enabling local units to accomplish public objectives. In recent years, the counties have been quite successful in securing whatever enabling legislation they desire. Many local government officials feel no special statutory or constitutional constraints on the scope of their responsibilties.

At the state level, the three agencies that have worked closely with localities in wastewater management were the Department of Health

principally through the Water Pollution Control Board, the Department of Natural Resources, and the Ohio Water Development Authority. Many of the functions of these agencies were transferred to the Ohio Environmental Protection Agency when it became functional on October 23, 1972. The Ohio EPA now will have authority over laws regulating water pollution, water planning and development, and the supervision of sewage treatment and public water supply facilities.

The Ohio Water Development Authority is both a supplier and coordinator of financial aid for wastewater treatment. If a political subdivision is under order to upgrade sewage treatment facilities, the OWDA can prefinance the FWQA grant and advance the remaining 70% of the project cost, which the local government must repay with interest. By May, 1972, OWDA had aided three completed projects in the Three Rivers watershed, and had in the application/partial construction stage an additonal 43 projects, at an estimated cost of 161 million dollars. These 43 projects, are administered by 17 municipalities and five counties. The county projects service 12 separate sewage collection areas.

With the magnitude of state financial interest in the Northeast Ohio region, it is of some interest to assess the policies of OWDA. There has been a substantial change in recent months. Instead of simply reviewing individual projects as self-contained entities, OWDA is now exercising a critical review function based upon regional criteria. Some applications from municipalities have been turned down because the projected sewer areas did not include additional areas that should be sewered in the future. In implementing this change of attitude, some local planning agencies have been signi-

ficant. For example, Tri-County Regional Planning Commission, which serves Portage, Medina, and Summit counties, has been working with the three county sanitary engineers in developing county-wide plans. Although attitudes and progress varies among the counties, it is clear that the Regional Planning Commission and the sanitary engineers are approaching policy agreements which would prohibit package plants and create larger sewer service areas to be served by single large plants. It appears that, through local county health department regulations, some counties may be proceeding toward a "no sewers, no development" policy.

c. Interest Group Activity

Functional interest groups, working as the "best friend and severest critic" of public planning agencies, have often provided the impetus toward innovative programs in American local government. In the development of voluntary association intrastructure, Northeast Ohio has tended to be as backward as it is in the strong support of regional planning. Most citizen's organizations in the region are new, and almost none have professional staff. Furthermore, they are concentrated in the city of Cleveland and Cuyahoga County. Of the seventeen county or area-wide citizens conservation groups that devote 100% of their time to environmental issues, only 8 are located outside of Cuyahoga County. The lack of staff and the uneven geographical distribution of organizations, as well as their newness and limited membership base, create a pattern of citizen activity that is sporadic and, by and large, weak.

d. Summary

In a systemic sense, Northeast Ohio suffers from a relatively low level of political integration, as compared with other metropolitan regions in the United States. A tradition of strong home rule has reinforced an atmosphere of competition among the subregions of which the study area is composed. This competition is reinforced by general uncertainities about the economic base, which is weakening in both the Akron and Cleveland areas. The low level of political integration produces unsophisticated and partial perceptions of regional problems, inhibits goal-setting at the regional level, and maintains a relatively dispersed pattern of voluntary citizen activity. On the other hand, recent developments indicate that the situation is in flux, with possibilities of regional action in certain parts of the study area, and a growing appreciation of a regional approach toward wastewater management. To what extent this nascent regionalism is tied to the conventional technology of wastewater management, or could be transferred to a new technology, is a matter of uncertain speculation.

e. New or Additional Treatment Facilities - Three Rivers Watershed

The following data are from the May 1, 1972 Progress Report of the Ohio Water Development Authority. OWDA was created in 1968 (ORC 6121) to assist local governments and industries in financing waste treatment facilities. The Local Government Agency Program prefinances the 30% FWQA grant and provides the remaining 70% which must be repaid with interest. In order to be eligible, a political subdivision must be under order of the Ohio Water Pollution Control Board to upgrade sewage treatment facilities. The Industrial Pro-

gram is financed by the issuance of OWDA revenue bonds, and the entire cost must be repaid. The incentive, of course, is an interest rate about 2% lower than industry could secure through ordinary business channels.

Under the LGA Program OWDA has aided 27 completed projects, for an estimated total cost of 13 million dollars. Three are located in the Three Rivers Watershed. An additional 291 projects are in the application/partial construction stage. The estimated total project cost is $691 million, of which $238 million has been committed in signed agreements. Seventy-six projects (26%) are located in the eight county region containing the Three Rivers Watershed.

The data in this table are restricted to (1) new projects located in the watershed itself, and (2) projects for new or additional treatment facilities. Projects for interceptor sewers only are not included. However, combined projects (new or additional facilities plus new interceptors) are included, and are indicated by an asterisk. Projects in one of the eight counties, but in another watershed, are not included.

In summary, the table reports on 43 projects, with an estimated cost of $161,339,674. They are administered by seventeen municipalities and five counties. The county projects serve 12 separate areas. These 43 projects comprise 23% of the total OWDA state-wide estimated project cost, and 27% of the OWDA.

In the third section of the table, the figures in parentheses are the project funds under signed agreements. The other figures are estimated project costs.

TABLE 28 CONSTRUCTION COMPLETED

Cuyahoga County		$ 1,583,035	
1. Berea (6/70)	$621,955		
2. Solon (1/72)	961,080		
Medina County		3,508,500	
*1. Co. Comm. (Brunswick area) (11/71)	$3,508,500		
TOTAL			$ 5,091,535

TABLE 29 UNDER CONSTRUCTION (SINCE 11/69)

Cuyahoga County		$14,393,899	
1. Cleveland (88% complete)	$8,852,970		
*2. North Olmsted (61% complete)	5,540,929		
Lake County		349,947	
1. Co. Comm. (Willoughby-Mentor) (44% complete)	349,497		
Portage County		993,592	
*1. Co. Comm. (S.D. #2-Twin Lakes) (99% complete)	993,592		
Stark County		850,949	
1. Hartville (11% complete)	850,949		
Summit County		6,152,346	
1. Akron (99% complete)	4,662,550		
2. Co. Comm. (N.E. S.D.) (99% complete)	1,489,796		
TOTAL			$22,740,283

TABLE 30 APPLICATIONS RECEIVED (Proposed/Under Construction)

Cuyahoga County			$ 85,770,952	($16,691,304)
1. Bedford	1,406,900	(0)		
2. Chagrin Falls	1,931,000	(2,297,405)		
3. Cleveland (5)	64,595,952	(8,852,970)		
4. Euclid	10,000,000	(0)		
*5. North Olmsted	4,077,000	(5,540,929)		
6. Strongsville (2)	3,760,100	(0)		
Geauga County			4,934,692	(780,000)
1. Burton	253,692	(0)		
*2. Co. Comm. (S. Russell Area)	1,338,000	(0)		
*3. Co. Comm. (Bainbridge Township)	1,932,000	(0)		
*4. Co. Comm. (Chardon Township)	$ 160,000	(0)		
*5. Co. Comm. (Chester S.D. #1)	501,000	(0)		
6. Chardon	750,000	(780,000)		
Lake County			$ 11,836,920	($ 9,915,597)
*1. Co. Comm. (Willoughby-Mentor) (2)	7,321,920	(5,065,597)		
2. Willoughby	430,000	(0)		
3. Willoughby-Eastlake	4,085,000	(4,850,000)		
Portage County			17,398,852	(1,172,192)
1. Aurora (including interceptors)	10,756,152	(0)		
*2. Co. Comm. (Kent Reg. S.D.)	970,000	(0)		
*3. Co. Comm. (Ravenna Reg. S.D.)	995,000	(0)		
*4. Co. Comm. (Twin Lakes Area)	2,795,700	(993,592)		
5. Ravenna	1,882,000	(1,786,000)		
Stark County			784,325	(850,949)
1. Hartville	784,325	(850,949)		
Summit County			12,782,115	(6,152,346)
1. Akron	4,359,886	(4,662,550)		
*2. Co. Comm. (Fish Cr.)	3,812,534	(0)		
*3. Co. Comm. (Macedonia)	1,815,635	(0)		
*4. Co. Comm. (N.E.S.D.)	1,260,000	(1,489,796)		
5. Northfield	497,500	(0)		
6. Twinsburg	1,036,560	(0)		
TOTAL			$133,507,856	($35,562,388)
GRAND TOTALS FOR 43 PROJECTS			$161,339,674	(Project Cost)
			63,394,206	(Funds Committed)

6. Economic Characteristics

The Three Rivers watershed area includes portions of the following counties: Cuyahoga, Geauga, Lake, Lorain, Medina, Portage, Stark, and Summit. Since data are generally not available specifically for the watershed area, the descriptions presented below relate to the entire area encompassed by these counties. Rather detailed information is available on a number of economic characteristics.

a. Population and Employment

In 1970 the watershed area (WA) housed approximately three and one-half million persons. Fifty percent of the WA population was located in Cuyahoga County with an additional thirty percent situated in Summit and Stark Counties. Recent years have witnessed a slow but significant change in the distribution of population within the area. Between 1966 and 1970 Cuyahoga County registered a two percent loss in population (35,000 persons). Summit County experienced a slight loss (.5% or 2,000 persons) during this period. The remaining six counties all showed population gains with Portage leading the way in both absolute and relative terms (19% and 20,000 persons). The population of the entire WA grew less than one per-

cent (26,000 persons). The area thus exhibited a slower rate of growth than either the nation (4.0%) or the State of Ohio (1.7%).

Comparable employment data were unavailable for both 1966 and 1970. The employment figures for 1969 and 1971 give the same general impression as did the population data but there are some significant differences. Cuyahoga County's share of WA employment in 1971 (57%) was greater than its share of WA population in 1970 (50%). For the two year period, a relatively rapid decline in employment occurred in both Cuyahoga (-2.7%) and Summit (-2.1%). In addition, smaller declines appeared in Lorain (-0.7%) and Stark (-0.04%). This is at least partially a result of rising unemployment rates which will be described below.

b. Income

The relative positions of the counties with respect to total income will, of course, rather closely reflect their employment positions. Per capita income figures, however, do convey different and useful information. In 1970 per capita effective buying income (EBI) in the WA ranged from $4058 in Cuyahoga to $2927 in Medina. The EBI in Cuyahoga was markedly higher than the EBI in the next most prosperous county (Summit with $3549). The national figure for per capita EBI in 1970 was $3308 and the corresponding state figure was $3355. Two counties in addition to Cuyahoga and Summit, had EBI's greater than the national and state averages: Lake ($3486) and Geauga ($3401). In general the WA appears relatively prosperous although some of its smaller counties do have incomes slightly below the national and state averages. All of these

figures should be interpreted with care, particularly with respect to intercounty differences within the WA. There are undoubtedly significant price level differences between counties that have not been taken into account in the estimation of the EBI's.

Between 1966 and 1970 all of the WA counties exhibited significant increases in per capita EBI. These increases ranged from 32% in Cuyahoga and 22% in Medina. The remaining six counties showed gains of between 25.6% and 28.3%. These gains, however, are not as impressive when viewed in the light of the 19.7% increase in the consumer price index during this period. Only one-third of the gains registered by Cuyahoga represent increases in real income and Medina shows very small gains in real terms. Furthermore, the WA in general showed smaller increases in EBI than either the nation (30.1%) or the state (29.7%).

c. Retail Sales

Once again, the aggregate figures on retail sales (RS) closely reflect the aggregate figures on population. The per capita figures are considerably different. Per capita RS ranged, in 1970, from $2079 in Lake to $113[illegible] in Geauga. Summit ($1584) and Cuyahoga ($1573) ranked fifth and sixth respectively. In addition to Lake, only Stark ($1892) and Lorain ($1796) were above the State of Ohio ($1748) and national ($1760) averages.

The growth in per capita retail sales from 1966-1970 was particularly slow in Summit (0.19%) and Cuyahoga (6.76%). This compares quite unfavorably to the state increase of 15.2% and the national increase of 15.1%. Per capita RS in the remaining six

counties of the watershed, however, increased faster than the state or national averages with the gains ranging from 18.5% in Portage to 56.3% in Lake. These figures seem to corroborate the changing location of economic activity in the watershed.

d. Unemployment

In 1971, the unemployment rate in the WA varied from 6.7% in Lorain to 3.9% in Summit. In addition to Summit, two counties, Medina (4.03%) and Cuyahoga (4.33%) had relatively low unemployment rates. The remaining four counties had rates between 5 and 6 percent. Comparable figures were unavailable on a state and national basis. These figures, however, are not too useful since they mask important inter-area variations. For instance, it is well known that the unemployment rates in certain portions of central city Cleveland are very high. This clearly is not reflected in the figure given for Cuyahoga County.

The unemployment rates increased markedly in each county from 1969 to 1971. The per capita increase ranged from 71 in Summit to 157 in Geauga. These figures are difficult to evaluate in the absence of a frame of reference, but they appear to show a high degree of cyclical vulnerability in the Watershed Area. The general picture that seems to emerge from these data is one of a relatively prosperous region that has been losing ground in recent years.

e. Employment By Industry

(1) Agriculture

For the complete Three Rivers Watershed area, agricultural employment dropped from 1.2% in 1960 to 0.9% in 1970. During this

TABLE 31 Population (1,000) for Counties in the Three Rivers Watershed

County	1960	1966	1967	1968	1969	1970	1970 Rank
Cuyahoga	1,670.3	1,763.0	1,746.5	1,766.7	1,769.7	1,728.1	1
(% Δ)		(5.5%)	(-1.0%)	(1.0%)	(0.2%)	(-2.4%)	
Geauga	50.4	59.3	61.2	62.4	64.1	63.9	8
(% Δ)		(17.6%)	(3.2%)	(1.9%)	(2.7%)	(-0.3%)	
Lake	159.1	181.4	191.9	194.2	195.7	197.9	5
(% Δ)		(14.0%)	(5.8%)	(1.2%)	(0.8%)	(1.1%)	
Lorain	225.3	255.4	266.5	266.5	266.5	258.6	4
(% Δ)		(13.3%)	(4.3%)	(0.0%)	(0.0%)	(-2.9%)	
Medina	68.5	75.1	79.0	78.6	80.4	83.0	7
(% Δ)		(9.6%)	(5.1%)	(-0.5%)	(2.3%)	(3.2%)	
Portage	95.0	108.3	110.6	115.4	119.1	128.1	6
(% Δ)		(14.0%)	(2.1%)	(4.3%)	(3.2%)	(7.6%)	
Stark	346.0	366.0	371.3	371.3	371.6	375.1	3
(% Δ)		(5.8%)	(1.4%)	(0.0%)	(0.08%)	(0.9%)	
Summit	523.7	559.4	569.0	569.0	569.6	557.3	2
(% Δ)		(6.8%)	(1.7%)	(0.0%)	(0.1%)	(-2.2%)	

Source: Sales Management, Inc. Survey of Buying Power, (Annually 1966 through 1971), New York.

TABLE 32 Effective Buying Income (net 1,000) for Counties in the Three Rivers Watershed

County	1960	1966	1967	1968	1969	1970
Cuyahoga	4,159,966	5,418,837	5,655,990	6,190,125	6,698,510	7,012,649
(%Δ)		(30.3%)	(4.3%)	(9.4%)	(8.2%)	(4.7%)
Geauga	94,018	160,574	176,419	192,881	214,767	217,295
(%Δ)		(70.8%)	(9.9%)	(9.3%)	(11.3%)	(1.2%)
Lake	367,486	503,105	560,813	609,202	666,609	689,870
(%Δ)		(36.9%)	(11.5%)	(8.6%)	(9.4%)	(3.5%)
Lorain	488,170	605,699	654,458	718,015	779,544	780,054
(%Δ)		(24.0%)	(8.1%)	(9.7%)	(8.6%)	(0.06%)
Medina	130,613	180,040	200,830	214,793	237,341	243,001
(%Δ)		(37.8%)	(11.5%)	(6.9%)	(10.5%)	(2.4%)
Portage	179,096	259,074	277,759	308,388	344,555	385,456
(%Δ)		(44.7%)	(7.2%)	(11.0%)	(11.7%)	(11.9%)
Stark	694,240	931,289	991,934	1,068,282	1,133,030	1,208,894
(%Δ)		(34.1%)	(6.5%)	(7.7%)	(6.1%)	(6.7%)
Summit	1,112,563	1,546,993	1,645,046	1,752,192	1,919,899	1,978,069
(%Δ)		(39.0%)	(6.3%)	(6.5%)	(9.6%)	(3.0%)

Source: Sales Management, Inc. Survey of Buying Power, (Annually 1966 through 1971), New York.

TABLE 33

Per Capita Effective Buying Income (net 1,000)
for Counties in the Three Rivers Watershed

County	1960	1966	1967	1968	1969	1970	1970 Rank
Cuyahoga	2,490.6	3,073.6	3,244.2	3,503.8	3,785.1	4,058.0	1
(%Δ)		(23.4%)	(5.6%)	(8.0%)	(8.0%)	(7.2%)	
Geauga	1,865.4	2,707.8	2,882.7	3,091.0	3,350.5	3,400.5	4
(%Δ)		(45.2%)	(6.5%)	(7.2%)	(8.4%)	(1.5%)	
Lake	2,309.8	2,773.5	2,922.4	2,136.9	3,406.2	3,485.9	3
(%Δ)		(20.0%)	(5.4%)	(7.3%)	(8.6%)	(2.3%)	
Lorain	2,166.8	2,371.5	2,456.2	2,694.2	2,925.1	3,016.5	6
(%Δ)		(9.4%)	(3.6%)	(9.7%)	(8.6%)	(3.1%)	
Medina	1,906.8	2,397.3	2,542.2	2,732.7	2,952.0	2,927.7	8
(%Δ)		(25.7%)	(6.0%)	(7.5%)	(8.0%)	(-0.8%)	
Portage	1,885.2	2,392.2	2,511.4	2,672.3	2,892.9	3,009.0	7
(%Δ)		(26.9%)	(4.9%)	(6.4%)	(8.3%)	(4.0%)	
Stark	2,006.5	2,544.5	2,671.5	2,877.1	3,049.1	3,223.7	5
(%Δ)		(26.8%)	(5.0%)	(7.7%)	(5.9%)	(5.7%)	
Summit	2,124.4	2,765.5	2,891.1	3,079.4	3,370.6	3,549.3	2
(%Δ)		(30.1%)	(4.5%)	(6.5%)	(9.5%)	(5.3%)	

Source: Sales Management, Inc. Survey of Buying Power, (Annually 1966 through 1971), New York.

TABLE 34 Retail Sales (1,000) for Counties in the Three Rivers Watershed

County	1960	1966	1967	1968	1969	1970	1970 Rank	1970 per Capita	1970 per Capita Rank
Cuyahoga	2,441,733	2,972,448	3,077,945	3,377,124	3,028,654	2,717,590	1	1,572.6	6
(% Δ)		(21.7%	(3.5%	(9.7%)	(-10.3%)	(-10.3%)			
Geauga	29,841	54,229	54,629	65,404	62,840	72,657	8	1,137.0	[illegible]
(% Δ)		(81.7%)	(0.7%)	(19.7%)	(-3.9%)	(15.6%)			
Lake	141,730	241,334	269,517	285,471	339,047	411,371	5	2,078.7	1
(% Δ)		(41.3%)	(11.7%)	(5.9%)	(18.8%)	(21.3%)			
Lorain	241,733	383,998	419,312	442,566	416,556	464,531	4	1,796.3	3
(% Δ)		(58.8%)	(9.2%)	(5.5%)	(-5.9%)	(11.5%)			
Medina	59,639	90,310	97,328	116,598	124,440	134,521	7	1,620.7	4
(% Δ)		(51.4%)	(7.8%)	(19.8%)	(6.7%)	(8.1%)			
Portage	74,136	132,324	136,567	155,122	166,344	185,458	6	1,447.8	7
(% Δ)		(78.5%)	(3.2%)	(13.6%)	(7.2%)	(11.5%)			
Stark	440,841	490,762	476,686	509,817	667,081	709,515	3	1,892.0	2
(% Δ)		(11.3%)	(2.9%)	(6.9%)	(30.8%)	(6.4%)			
Summit	666,543	887,910	918,286	991,496	943,773	882,706	2	1,583.9	5
(% Δ)		(33.2%)	(3.4%)	(8.0%)	(-4.8%)	(-6.5%)			

Source: Sales Management, Inc. Survey of Buying Power (Annually 1966 through 1971), New York.

TABLE 35

Employment, Unemployment, and Unemployment Rate
for Counties in the Three Rivers Watershed

County	Employment 1969	Employment 1971	Unemployment 1969	Unemployment 1971	Unemployment Rate 1969	Unemployment Rate 1971
Cuyahoga	840,900	818,067	17,567	37,000	2.07	4.33
(% Δ)		(-2.7%)		(110.6%)		(109.2%)
Geauga	14,767	15,850	333	967	2.23	5.73
(% Δ)		(7.3%)		(190.4%)		(156.9%)
Lake	54,000	57,067	1,233	3,233	2.20	5.33
(% Δ)		(5.7%)		(162.2%)		(142.3%)
Lorain	87,933	87,300	3,533	6,267	3.83	6.67
(% Δ)		(-0.7%)		(77.4%)		(74.1%)
Medina	20,967	23,650	500	1,000	2.33	4.03
(% Δ)		(12.8%)		(100.0%)		(73.0%)
Portage	35,900	38,733	967	2,367	2.67	5.80
(% Δ)		(7.9%)		(144.8%)		(117.2%)
Stark	149,200	149,133	3,767	7,867	2.47	5.00
(% Δ)		(-0.04%)		(108.8%)		(102.4%)
Summit	232,033	227,033	5,433	8,967	2.30	3.93
(% Δ)		(-2.1%)		(65.0%)		(70.9%)

Source: Sales Management, Inc. Survey of Buying Power, (Annually 1966 through 1971), New York.

Table 36 Industrial Composition of the Three Rivers Watershed Area: 1960

Industry	Cuyahoga No.	Cuyahoga (%)	Geauga No.	Geauga (%)	Lake No.	Lake (%)	Lorain No.	Lorain (%)	Medina No.	Medina (%)
TOTAL	642,835		16,647		53,582		75,758		22,776	
Agriculture	2,192	0.3	1,059	6.4	1,096	2.0	2,222	2.9	1,610	7.1
Forestry & Fisheries	23	.00003	16	0.09	29	0.05	--	- -	4	0.02
Mining	652	0.1	80	0.5	118	0.2	404	0.5	84	0.4
Construction	27,013	4.2	1,335	8.0	2,939	5.5	3,501	4.6	1,284	5.6
<u>Manufacturing</u>	248,712	38.7	6,331	38.0	25,962	48.5	34,331	45.3	9,197	40.4
Furniture & Lumber & Wood Products	4,126	0.6	145	0.9	254	0.5	106	0.1	73	0.3
Primary Metal Ind.	37,323	5.8	435	2.6	1,200	2.2	11,018	14.5	825	3.6
Fabric'd Metal Ind. (Inc. not Spec. Metal)	27,682	4.3	459	2.8	1,813	3.4	4,341	5.7	1,809	7.9
Machinery except Electrical	36,395	5.7	1,137	6.8	5,177	9.7	2,334	3.1	597	2.6
Electrical Mach. Equip. & Supplies	23,413	3.6	752	4.5	2,389	4.5	1,307	1.7	256	1.1
Motor Vehicles & Motor Veh. Equip.	33,142	5.2	532	3.2	2,321	4.3	8,702	11.5	1,484	6.5
Transp. Equip. exc. Motor Veh.	9,820	1.5	347	2.1	1,884	3.5	1,009	1.3	173	0.8
Other Durable Goods	10,151	1.6	425	2.6	1,141	2.1	1,064	1.4	1,152	5.1
Food and Kindred Prod.	13,508	2.1	187	1.1	653	1.2	777	1.0	519	2.3
Textile Mill Products	3,327	0.5	40	0.2	1,058	1.9	62	0.08	17	0.07
Apparel & Other Fabric'd Products	7,892	1.2	76	0.5	210	0.4	121	0.2	40	0.2
Printing, Publish. & Allied Products	17,109	2.7	361	2.2	1,133	2.1	1,257	1.7	416	1.8
Chemical & Allied Products	12,734	1.9	239	1.4	4,629	8.6	1,520	2.0	442	1.9
Other Non-Dur. Goods (Inc. not Spec. Mfg.)	11,790	1.8	1,196	7.2	2,100	3.9	713	0.9	1,394	6.1
Railroad & Railway Express Service	10,943	1.7	138	0.8	809	1.5	1,172	1.5	241	1.1
Trucking Service & Warehousing	9,546	1.4	247	1.5	591	1.1	1,202	1.6	647	2.8

Table 36 (con't)

	Cuyahoga		Geauga		Lake		Lorain		Medina	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Wholesale Trade	35,148	5.0	617	2.6	2,302	3.0	2,083	2.2	1,194	3.8
Food & Dairy Prod. Stores	17,988	2.6	535	2.2	1,904	2.4	2,532	2.6	713	2.3
Eating & Drinking Places	20,051	2.9	582	2.4	1,954	2.5	2,803	2.9	920	2.9
Gen. Merchandise Retailing	23,691	3.4	480	2.0	2,996	3.8	3,019	3.1	646	2.1
Mtr. Vehicle Retailing & Service Stations	11,140	1.6	677	2.8	1,553	2.0	1,953	2.0	1,027	3.3
Other Retail Trade	31,719	4.5	919	3.9	2,884	3.7	3,913	4.1	1,261	4.0
Banking & Credit Agen.'s	13,278	1.9	338	1.4	1,068	1.4	1,227	1.3	355	1.1
Insurance, Real Estate & Other Finance	21,722	3.1	510	2.1	1,509	1.9	1,453	1.5	965	3.1
Business & Repair Svcs.	24,378	3.5	758	3.2	2,218	2.8	2,310	2.4	718	2.3
Private Households	6,114	0.9	349	1.4	410	0.5	668	0.7	213	0.7
Other Personal Services	18,954	2.7	405	1.7	1,517	1.9	2,143	2.2	581	1.9
Entertainment & Recreation Services	4,877	0.7	218	0.9	552	0.7	665	0.7	232	0.7
Hospitals	28,243	4.0	601	2.5	1,695	2.2	2,996	3.1	773	2.5
Health Svcs. exc. Hosp.	11,873	1.7	513	2.1	1,027	1.3	1,902	2.0	621	2.0
Educational Svcs:										
Government	28,143	4.0	1,114	4.7	3,180	4.1	4,340	4.5	1,470	4.7
Private	14,490	2.0	474	2.0	1,224	1.6	2,414	2.5	332	1.0
Other Educ. & Related Services	3,600	0.5	100	0.4	290	0.4	372	0.4	67	0.2
Welf., Relig., & Non-Profit Membership Orgs.	10,012	1.4	282	1.2	677	0.9	1,310	1.3	224	0.7
Other Professional & Related Services	20,315	2.9	580	2.4	1,452	1.9	1,527	1.6	437	1.4
Public Administration	32,310	4.6	515	2.1	1,913	2.4	3,083	3.2	899	2.9

Source: U.S. Bureau of the Census, 1970, PC(1) C37, Table 123.

Table 36 (con't)

Industrial Composition of the Three Rivers Watershed Area: 1960

Industry	Portage No.	Portage (%)	Stark No.	Stark (%)	Summit No.	Summit (%)	TOTAL No.	TOTAL (%)
TOTAL	31,054		120,895		188,960		1,152,507	
Agriculture	1,539	5.0	2,313	1.9	1,330	0.7	13,361	1.2
Forestry & Fisheries	5	0.01	5	0.004	--	--	82	0.007
Mining	207	0.7	395	0.3	266	0.1	2,206	0.2
Construction	1,925	6.2	5,173	4.3	7,673	4.1	50,843	4.4
Manufacturing	12,099	38.9	53,431	44.2	84,554	44.7	474,667	41.2
Furniture & Lumber & Wood Products	204	0.7	1,077	0.9	585	0.3	6,570	0.6
Primary Metal Ind.	885	2.8	16,527	13.7	1,906	1.0	70,119	6.1
Fabric'd Metal Ind. (Inc. not Spec. Metal)	977	3.3	5,517	4.6	7,790	4.1	50,388	4.4
Machinery except Electrical	1,696	5.5	12,338	10.2	5,831	3.1	65,505	5.7
Electrical Mach. Equip. & Supplies	882	2.8	3,592	2.9	1,053	0.5	33,644	2.9
Motor Vehicles & Motor Veh. Equip.	1,949	6.3	769	0.6	3,287	1.7	52,186	4.5
Transp. Equip. exc. Motor Veh.	548	1.8	835	0.7	5,789	3.1	20,405	1.8
Other Durable Goods	786	2.5	3,635	3.0	3,615	1.9	21,969	1.9
Food and Kindred Prod.	367	1.2	3,470	2.9	2,948	1.6	15,385	1.3
Textile Mill Products	92	0.3	24	0.02	63	0.03	4,683	0.4
Apparel & Other Fabric'd Products	20	0.06	198	0.2	220	0.1	8,777	0.8
Printing, Publish. & Allied Products	358	1.2	1,875	1.6	2,996	1.6	25,505	2.2
Chemical & Allied Products	140	0.5	556	0.5	3,325	1.8	23,585	2.0
Other Non-Dur. Goods (Inc. not Spec. Mfg.)	3,195	10.3	3,068	2.5	45,146	23.9	68,602	5.9
Railroad & Railway Express Service	422	1.4	2,328	1.9	1,358	0.7	17,411	1.5
Trucking Service & Warehousing	681	2.2	1,779	1.5	5,334	2.8	20,027	1.7

Table 36 (con't)

	Portage		Stark		Summit		TOTAL	
	No.	(%)	No.	(%)	No.	(%)	No.	(%)
Wholesale Trade	1,044	2.2	5,288	3.7	7,647	3.6	55,323	4.2
Food & Dairy Prod. Stores	1,098	2.3	3,510	2.5	5,309	2.5	33,589	2.5
Eating & Drinking Places	1,817	3.8	4,506	3.2	7,153	3.3	39,786	3.0
Gen. Merchandise Retailing	746	1.6	3,811	2.7	8,268	3.9	43,657	3.3
Mtr. Vehicle Retailing & Service Stations	1,048	2.2	3,089	2.2	4,910	2.3	25,397	1.9
Other Retail Trade	2,262	4.8	7,132	5.0	9,257	4.3	59,347	4.5
Banking & Credit Agen.'s	445	0.9	2,225	1.6	2,759	1.3	21,695	1.6
Insurance, Real Estate & Other Finance	737	1.6	2,984	2.1	4,819	2.3	34,699	2.6
Business & Repair Svcs.	839	1.8	3,399	2.4	5,953	2.8	40,573	3.1
Private Households	293	0.6	1,201	0.8	1,795	0.8	11,043	0.8
Other Personal Services	1,011	2.1	3,277	2.3	5,678	2.7	33,566	2.5
Entertainment & Recreation Services	387	0.8	870	0.6	1,612	0.8	9,413	0.7
Hospitals	1,123	2.3	5,243	3.7	8,089	3.8	48,763	3.7
Health Svcs. exc. Hosp.	681	1.4	2,716	1.9	3,549	1.6	22,882	1.7
Educational Svcs:								
Government	5,806	12.3	5,659	4.0	10,391	4.9	60,103	4.5
Private	1,046	2.2	2,129	1.5	2,610	1.2	24,719	1.9
Other Educ. & Related Services	149	0.3	467	0.3	768	0.4	5,813	0.4
Welf., Relig., & Non-Profit Membership Orgs.	484	1.0	2,027	1.4	3,468	1.6	18,484	1.4
Other Professional & Related Services	1,171	2.5	2,385	1.7	3,455	1.6	31,322	2.4
Public Administration	968	2.0	3,472	2.5	6,176	2.9	49,336	3.7

Table 37 Industrial Composition of the Three Rivers Waters'ed Area: 1970

Industry	Cuyahoga No.	Cuyahoga (%)	Geauga No.	Geauga (%)	Lake No.	Lake (%)	Lorain No.	Lorain (%)	Medina No.	Medina (%)
Industry	695,800		23,807		77,766		95,385		31,212	
Agriculture, Forestry & Fisheries	3,240	0.4	828	3.5	885	1.1	1,761	1.8	1,109	3.5
Mining	1,255	0.2	110	0.4	268	0.3	161	0.2	154	0.5
Construction	30,258	4.3	1,777	7.4	3,937	5.0	4,478	4.7	1,975	6.3
Manufacturing	235,084	33.8	9,281	38.9	36,486	46.9	40,800	42.7	12,121	38.8
Furniture & Lumber & Wood Products	2,980	4.3	228	0.9	224	0.3	152	0.15	212	0.7
Metal Industries	58,263	8.4	1,263	5.3	6,558	8.4	15,331	16.0	2,843	9.1
Machinery except Elec.	37,176	5.3	1,718	7.2	7,620	9.8	3,332	3.5	1,594	5.1
Electrical Machinery Equip. & Supplies	22,818	3.3	1,242	5.2	4,039	5.2	1,667	1.7	317	1.0
Transportation Equip. (Inc. Motor Veh.)	34,914	5.0	983	4.1	4,546	5.8	11,866	12.4	2,000	6.4
Other Durable Goods	22,334	3.2	789	3.3	3,606	4.6	2,750	2.9	1,334	4.2
Food and Kindred Prod.	6,907	1.0	275	1.1	446	0.6	530	0.5	347	1.1
Textiles & Fabricated Textile Products	9,165	1.3	76	0.3	1,301	1.7	426	0.4	208	0.7
Printing, Publishing & Allied Products	14,156	2.0	464	1.9	1,265	1.6	1,229	1.3	523	1.7
Chemical & Allied Prod.	11,982	1.7	416	1.7	4,223	5.4	1,926	2.0	633	2.0
Other Non-Durable Goods (Inc. not Spec. Mfg.)	14,029	2.0	1,827	7.6	2,658	3.4	1,591	1.6	2,110	6.7
Railroad & Railway Express Service	6,017	0.8	114	0.5	757	1.0	861	1.0	137	0.4
Trucking Service & Warehousing	10,539	1.5	405	1.7	724	0.9	1,027	1.1	946	3.0
Other Transportation	8,718	1.2	189	0.8	546	0.7	906	0.9	303	1.0
Communications	11,497	1.6	272	1.1	827	1.0	1,022	1.1	438	1.4
Utilities & Sanitary Svc.	11,146	1.6	264	1.1	1,011	1.3	1,656	1.7	381	1.2

Table 37 (con't)

Industry	Cuyahoga No.	Cuyahoga (%)	Geauga No.	Geauga (%)	Lake No.	Lake (%)	Lorain No.	Lorain (%)	Medina No.	Medina (%)
Other Transportation	7,941	1.2	117	0.7	448	0.8	878	1.2	189	0.8
Communications	7,811	1.2	170	1.0	604	1.1	652	0.9	275	1.2
Utilities & Sanitary Service	8,533	1.3	123	0.7	564	1.1	1,202	1.6	309	1.4
Wholesale Trade	25,723	4.0	345	2.1	1,083	2.0	1,063	1.4	540	2.4
Food & Dairy Product Stores	17,020	2.6	433	2.6	1,321	2.5	1,954	2.6	459	2.0
Eating & Drinking Places	18,003	2.8	268	1.6	1,146	2.1	2,308	3.0	594	2.6
Other Retail Trade	54,564	8.5	1,363	8.2	4,341	8.1	6,314	8.3	2,030	8.9
Finance, Insurance & Real Estate	26,681	4.2	461	2.8	1,683	3.1	2,023	2.7	985	4.3
Business Services	9,669	1.5	227	1.4	493	0.9	448	0.6	134	0.6
Repair Services	6,815	1.1	266	1.6	597	1.1	776	1.0	259	1.1
Private Households	12,582	1.9	417	2.5	935	1.7	1,229	1.6	303	1.3
Other Personal Services	16,841	2.6	260	1.6	948	1.8	1,626	2.1	337	1.5
Entertainment & Recreation Services	4,858	0.7	142	0.9	347	0.6	491	0.6	114	0.5
Hospitals	19,810	3.1	271	1.6	754	1.4	1,533	2.0	454	1.9
Educational Services:										
Government	17,516	2.7	825	4.9	2,042	3.8	2,296	3.0	793	3.5
Private	9,798	1.5	182	1.1	679	1.3	1,425	1.9	82	0.4
Welf., Relig., & Non-Profit Membership Orgs.	8,383	1.3	134	0.8	391	0.7	834	1.1	265	1.2
Other Professional & Related Services	16,980	2.6	333	2.0	1,177	2.2	1,437	1.9	489	2.1
Public Administration	27,180	4.2	373	2.2	1,330	2.5	1,764	2.3	505	2.2
Industry not Reported	27,046	4.2	731	4.4	1,155	2.2	2,673	3.5	593	2.6

Source: U.S. Bureau of the Census, U.S. Census of Population: 1960. General Social & Economic Characteristics, OHIO, Final Report PC(1)-37C, Table 85.

Table 37 Industrial Composition of the Three Rivers Watershed Area: 1970 (Con't)

Industry	Portage No. 47,306	Portage (%)	Stark No. 141,260	Stark (%)	Summit No. 212,757	Summit (%)	TOTAL No. 1,325,293	TOTAL (%)
Agriculture, Forestry & Fisheries	1,002	2.1	1,585	1.1	1,444	0.7	11,854	0.9
Mining	146	0.3	408	0.3	276	0.1	2,778	0.2
Construction	2,742	5.8	6,433	4.5	9,319	4.4	60,919	4.6
<u>Manufacturing</u>	17,770	37.6	59,262	41.9	84.387	39.6	495,191	37.4
Furniture & Lumber & Wood Products	277	0.6	960	0.7	683	0.3	5,716	0.4
Metal Industries	4,029	8.5	22,385	15.8	14,179	6.6	125,211	9.4
Machinery except Elec.	2,531	5.3	12,265	8.7	9,487	4.4	75,723	5.7
Electrical Machinery Equip. & Supplies	1,193	2.5	4,419	3.1	1,825	0.8	37,520	2.6
Transportation Equip. (Inc. Motor Veh.)	1,708	3.6	2,036	1.4	6,454	3.0	64,507	4.9
Other Durable Goods	1,472	3.1	5,177	3.6	4,649	2.2	42,111	3.2
Food and Kindred Prod.	366	0.8	2,614	1.8	2,184	1.0	13,669	1.0
Textiles & Fabricated Textile Products	122	0.2	353	0.2	422	0.2	12,073	0.9
Printing, Publishing & Allied Products	440	0.9	2,126	1.5	2,416	1.1	22,619	1.7
Chemical & Allied Prod.	348	0.7	677	0.5	3,239	1.5	23,444	1.8
Other Non-Durable Goods (Inc. not Spec. Mfg.)	5,284	11.2	6,250	4.4	38,849	18.2	72,598	5.5
Railroad & Railway Express Service	254	0.5	1,635	1.2	1,026	0.5	10,801	0.8
Trucking Service & Warehousing	1,024	2.1	2,194	1.5	5,969	2.8	22,828	1.7
Other Transportation	312	0.7	628	0.4	868	0.4	12,470	0.9
Communications	381	0.8	1,396	1.0	2,730	1.2	18,563	1.4
Utilities & Sanitary Svc.	520	1.1	2,329	1.6	3,072	1.4	20,379	1.5

Table 37 (con't)

Industry	Portage No.	Portage (%)	Stark No.	Stark (%)	Summit No.	Summit (%)	TOTAL No.	TOTAL (%)
Other Transportation	231	0.7	404	0.3	982	0.5	11,190	1.0
Communications	296	0.9	961	0.8	2,147	1.1	12,916	1.1
Utilities & Sanitary Service	308	1.0	1,677	1.4	2,763	1.5	15,479	1.3
Wholesale Trade	537	1.7	3,382	2.8	4,845	2.6	37,518	3.3
Food & Dairy Product Stores	920	2.9	3,391	2.8	4,552	2.4	30,050	2.6
Eating & Drinking Places	1,140	3.7	3,421	2.8	5,396	2.9	32,276	2.8
Other Retail Trade	2,642	8.5	11,093	9.2	17,352	9.2	99,699	8.7
Finance, Insurance & Real Estate	597	1.9	3,666	3.0	5,979	3.2	42,075	3.7
Business Services	131	0.4	845	0.7	1,924	1.0	13,871	1.2
Repair Services	386	1.2	1,478	1.2	2,486	1.3	13,063	1.1
Private Households	635	2.0	2,294	1.9	3,683	1.9	22,078	1.9
Other Personal Services	538	1.7	2,693	2.2	4,684	2.5	27,927	2.4
Entertainment & Recreation Services	248	0.8	810	0.7	1,460	0.8	8,470	0.7
Hospitals	520	1.7	3,819	3.2	5,602	2.9	32,763	2.8
Educational Services:								
Government	2,697	8.7	3,720	3.1	6,138	3.2	36,027	3.1
Private	379	1.2	1,119	0.9	1,626	0.9	15,290	1.3
Welf., Relig., & Non-Profit Membership Orgs.	342	1.1	1,565	1.3	2,715	1.4	14,629	1.3
Other Professional & Related Services	440	1.4	2,571	2.1	3,991	2.1	27,418	2.4
Public Administration	722	2.3	2,845	2.4	4,901	2.6	39,620	3.4
Industry not Reported	467	1.5	3,667	3.0	5,219	2.8	41,551	3.6

Source: U.S. Bureau of the Census, U.S. Census of Population: 1960. General Social & Economic Characteristics, OHIO, Final Report PC(1)-37C, Table 85.

period, Medina, Geauga, and Portage counties maintained agricultural work forces well above the watershed average, with Cuyahoga the lowest ranking county in agricultural employment. Even for those counties with above average agricultural employment, however, a significant decrease occurred from 1960-1970, with Medina dropping from 7.1% to 3.5%, Geauga from 6.4% to 3.5%, and Portage from 5.0% to 2.1%.

(2) Manufacturing

The manufacturing sector dropped from an employment rate of 41.2% of the total watershed area work force in 1960 to 37.4% in 1970. Durable goods (excluding "Furniture and Lumber and Wood Products") maintain the bulk of employment in manufacturing industries having 66% of manufacturing sector employment in 1960 rising to 69% in 1970. This increase during the decade, however, aggregatively masks significant changes within the durable good industries. Substantial decreases occurred in "Metal Industries" and "Motor Vehicles and Motor Vehicle and Transportation Equipment," while 1970 employment nearly doubled for the "Other Durable Goods" industries. These trends appear to indicate a more diversified durable goods manufacturing mix within the Three Rivers Watershed area.

On an individual county basis, Lake ranks highest with 48.5% of its work force employed in manufacturing industries in 1960, dropping to the 1970 watershed area high of 46.9% in 1970. While Geauga ranked lowest in 1960 with 38.0%, Cuyahoga holds the 1970 low with 33.8%. Lorain, Stark and Summit are close in relatively high area ranking to Lake, although Summit experienced a somewhat substantial drop from 44.7% in 1960 to 39.6% in 197 .

Employment in "Machinery except Electrical" in Stark and the "Motor Vehicle and Motor Vehicle & Transportation Equipment," industry in Lorain plus the "Metal Industries" in both counties account for over 50% of their work forces employed in manufacturing throughout the period 1960-1970.

Lake County had approximately 48% of its manufacturing work force employed in the "Chemical & Allied Products" industry and in the "Machinery except Electrical" production in 1960. However, a shift occurred during the decade, with 1970 figures evidencing a sharp decrease in the chemical industry balanced by a substantial increase in employment in "Metal Industries."

In Summit County, over 50% of the county's manufacturing work force (or 23.9% of the entire county's employment) were in those industries included in the category "Other Non-durable Goods" in 1960. A 5% drop in the county's decrease in manufacturing from 44.7% to 39.6% in 1970.

"Other Non-durable Goods" was also the dominating category in Portage in 1960 (10.3% of total county employment), with other important manufacturing industries being "Motor Vehicles and Motor Vehicle Equipment" (6.3%) and "Machinery except Electrical" (5.5%). While the "Other Non-durable Goods" industries showed a slight gain in 1970, Portage's manufacturing employment substantially declined in "Motor Vehicles" with an increase in "Metal Industries."

Geauga was the only watershed area county to show an employment gain in manufacturing industries from 1960-1970 (a rise from 38.0% to 38.9%). Increases were generally evenly distributed throughout the manufacturing sector, with dominating employment in "Other

Non Durable Goods" and "Machinery except Electrical," together comprising a total manufacturing employment rate of 37% in 1960 and 38% in 1970.

Significant manufacturing employment in Medina County is in "Metal Industries," "Motor Vehicle and Motor Vehicle & Transportation Equipment," and "Other Non-durable Goods." The county's total manufacturing work force slightly declined during the decade, with a generally even distribution among the sector. The one exception to the general decrease was the approximate doubling of Medina's employment in the "Machinery except Electrical" industry during the 1960-70 period (from 2.6% to 5.1%).

The 1960 distribution of manufacturing employment in Cuyahoga County was very similar to that found in the entire watershed area. This is due in large part to the dominant size of Cuyahoga County. However, in comparisons of 1970 manufacturing employment figures, Cuyahoga experienced the sharpest overall decline in the manufacturing sector, with a drop from 38.7% to 33.8%. This appears to reflect the trend of industrial decentralization away from Cuyahoga's dense population concentrated in the Cleveland area.

(3) Other Non Manufacturing Industries

Employment in mining is negligible in the watershed area, accounting for only 0.2% of the labor force employment in both 1960 and 1970.

Construction dropped slightly from 4.4% of the total watershed area's employment in 1960 to 4.2% in 1970. Geauga ranks highest with an 8.7% 1960 construction employment rate, falling

to 7.4% in 1970. Medina showed a gain from 5.6% to 6.3% in construction labor during the decade, with the other counties approximating the watershed average.

In the total watershed area, 3.1% of the labor force were employed in government educational services in 1960, rising to 4.5% in 1970. Of the individual counties, Portage was highest in 1960 with 8.7%, and again in 1970 with an increase to 12.3%. Cuyahoga's 1960 area low of 2.7% showed a gain of 4.0% in 1970.

The remaining industries are distributed rather evenly throughout the watershed area.

f. <u>Lake Erie Fishing Industry</u>

The fishing industry in Lake Erie is one that has most obviously been affected by the growing pollution loads contributed by the entire watershed. The changes are best indicated by a brief history. Since 1920, the combined U.S. and Canadian catch has averaged approximately 50 million pounds annually. Prior to 1954, U.S. fishermen landed more pounds annually than Canadian fishermen, but the present U.S. catch is less than 20% of the total catch.

Although the total number of pounds has been relatively constant, the value of the catch has been steadily declining. The decline in value reflects the changing composition of the catch: fewer high-value and more low-value fish are now being taken. Before 1913, the sturgeon, cisco, whitefish, and northern pike yields did not vary significantly. By the 1920's the population of sturgeon and northern pike were virtually depleted. Cisco and whitefish thus became increasingly important. By 1955, the cisco were

commercially extinct; whitefish landing abruptly decreased in 1955 and has now been virtually eliminated. The high-valued blue pike, which were second in abundance in 1920, dropped from over 10 million pounds in 1957 to less than two million pounds in 1958. The blue pike is presently on the national endangered species list. Saugers, which were fourth in abundance in 1920, began to decline in 1945--and are now nearly extinct in Lake Erie. The walleye, the last abundant high valued fish, has been in serious decline since 1956.

The heated discharges from the increasing number of power plants on Lake Erie may have very damaging effects on fishing and the associated aquatic resources. Warm water temperatures and high nutrient levels have led to tremendous algae blooms. The algae eventually have caused widespread oxygen depletion in the bottom waters of the western and central basins during periods of summer thermal stratification. This has resulted in the destruction of many organisms which are vital in thydiets of Lake Erie fish. The rising water temperature is also disrupting the spawning and incubation periods of the valuable walleye.

Among the many pollutants discharged into Lake Erie, pesticide levels are moderately low and under the safety level, but mercury levels are dangerously high.

In 1969 research on the walleye spawning season was conducted. The results of this research suggest that the smothering effect of sedimentation on fish eggs and other bottom organisms may be a major factor in the decline of the more valuable fish stocks in Lake Erie. About 15 million tons of sediment are carried into Lake Erie annually and at least as much is eroded off the shoreline each year.

TABLE 38 LAKE ERIE FISH CATCH 1920-1969

Species	Rank 1920	Total Lake Erie Rank 1969	Total Lake Erie No. of pounds 1969	% of Total Lake Erie	Ohio No. of pounds 1969	Ohio % of Total Ohio	Ohio Value	Trend & Comment
Walleye	9	6	475,151	.80%	139,302	.46%	high	Catch rose from mid-1930's to a high of 15.5 million pounds in 1956. Since that date, the no. of pounds has dropped to pre-1935 levels.
Whitefish/ Cisco			2,321	.004%	746	.008%	high	These two species have drastically declined and are nearly extinct.
--Whitefish	6	>10					high	
--Cisco	1	>10					high	
Yellow Perch	5	1	33,166,339	56.14%	2,660,536	27.88%	medium	The 1969 landing is highest ever recorded but a downward trend is forecast beginning in 1970.
White Bass	>10	5	2,093,526	3.54%	1,155,867	12.11%	medium	Since 1952, annual landings have ranged from 2.0 to 9.0 million pounds annually.
Channel Catfish	10	7	837,539	1.42%	713,465	7.48%	medium	Since 1955, annual landings ranged from 1.2 to 2.0 million pounds but over-exploitation may be occurring since landings decreased in 1969.
Freshwater Drum	7	4	2,399663	4.06%	1,992,877	20.89%	low	This has always been plentiful, and has increased since 1959.
Smelt	Not yet in Lake Erie.	2	15,077,695	25.52%	464	.005%	low	First reported in Lake Erie in 1932, but not commercially important until early 1950's. The species has been surviving well.

TABLE 38 (cont.) LAKE ERIE FISH CATCH 1920-1969

Species	Rank 1920	Total Lake Erie Rank 1969	Total Lake Erie No. of Pounds 1969	% of Total Lake Erie	Ohio No. of Pounds 1969	Ohio % of Total Ohio	Ohio Value	Trend & Comment
Bullhead	>10	10	54,984	.09%	35,030	.36%	low	These 4 species have been increasing in abundance, but they are not very useful.
Carp	3	3	3,209,304	5.43%	2,586,849	27.11%	low	
Goldfish/ hybrid	>10	9	98,912	.17%	98,912	1.04%	low	
Suckers	8	8	189,039	.32%	110,200	1.15%	low	
High value other			1,589	.003%	-0-	-0-	high	Includes: Blue Pike, Northern Pike, Sturgeon, Saugers, etc.
Medium value other			99,843	.17%	-0-	-0-	medium	Includes: Rock bass, Crappies, Sunfishes, etc.
Low value other			1,369,615	2.32%	46,621	.49%	low	Includes: Mooneye, Burbot, Eels, Bowfin, etc.
TOTAL			59,075,520	99.98%	9,540,869	99.98%		

Ohio, Pennsylvania, and New York have annually been releasing coho salmon into their state tributary waters. Except for reportedly good growth and survival, little is known about their impact on the other valuable commercial and sport fish. The coho salmon are for sportsmen only, and commercial landings are presently prohibited in Lake Erie. To the best of our knowledge, there are no published data of the fish catches in the Three Rivers Watershed area.

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VI. EVALUATION OF ENVIRONMENTAL IMPACTS OF LAND-BASED AND WATER-BASED ADVANCED WASTEWATER TREATMENT TECHNOLOGIES

A. INTRODUCTION

Interaction between designers, evaluators, and Corps personnel produced twelve alternative plans for wastewater treatment within the target area. Two general evaluation needs emerged over time. First, it was obvious that environmental impact would be a function of the choice of treatment technology. At the most general level this was a matter of water discharge of effluent versus land discharge. Second, we recognized that each alternative plan consisted of a different mix of certain basic system components. Each component in a wastewater treatment system has an impact of its own and can be evaluated in its own right. Awareness of this fact plus an understanding of the components can aid regional planners in tailoring a system to meet local needs. It becomes particularly useful in adapting existing facilities to new treatment possibilities.

Five major systems components were identified and evaluated; wastewater sources, wastewater collection, wastewater treatment, treatment residuals, and residue disposal. it is important to be aware of the implications of differences in these components upon the overall wastewater management system.

In this section of our report we present an extended discussion of the ecological impact of land discharge and treatment of secondary effluent versus biological-chemical-physical treatment with water discharge, and, in addition, our evaluation of the systems' components. Our presentation of these general factors is intended

to give the reader an appreciation for the relative merits/demerits of these particular approaches to wastewater management before he tackles the individual plan evaluations.

B. ECOLOGICAL AND OTHER ENVIRONMENTAL CONSIDERATIONS

1. Introduction

Protection and enhancement of ecosystem characteristics related to Man's ability to exist as a biological species is of fundamental importance in projects of this type, with their potential for massive intervention in nature. Recognizing this absolute fact, we present the following evaluation of the relative impact of land- and water-treatment technologies.

In view of the attributes that characterize mature, stable, and "healthy" ecosystems, the following guidelines were used to aid in the selection of wastewater alternatives. Those management alternatives that (1) exhibit the greatest reliability and flexibility; (2) have the greatest potential for reuse of solid and liquid residuals; (3) have the least detrimental impact on in-basin and out-basin ecosystems; and (4) promote stabilization and rehabilitation of disturbed ecosystems are given the highest priority.

In addition to these general guidelines, questions relating to possible ecological impacts of wastewater alternatives were developed. A magnitude value of 3 is assigned to the wastewater treatment alternative that creates the most desirable effect; a value of 1 or 2 has been assigned to alternatives that cause intermediate effects; and a value of 0 is assigned to alternatives that cause the most undesirable ecological impact or that contribute least to correcting an existing environmental problem.

An <u>importance</u> value also has been assigned to each question relating to possible ecological impact. A value of 10 has been assigned to the most important ecological factors; a value of 5 assigned to factors of intermediate importance; and a value of 1 assigned to the least important factors.

For convenience in discussing the ecological impact of each wastewater management alternative, the following regions or ecosystems have been delineated:

a. Streams and rivers within the Three Rivers Watershed.

b. Streams and rivers within the proposed land treatment areas of North-Central Ohio.

c. Land treatment sites within the Three Rivers Watershed.

d. Land treatment sites in North-Central Ohio.

e. Stripmined areas of Southeastern Ohio.

f. Lake Erie.

The impact of each alternative technology is discussed in terms of effects on biological energetics, the structure of biological communities, nutrient cycling, life histories and growth patterns of organisms, and overall homeostatic control mechanisms for each of the ecosystems listed above.

In general, changes in wastewater treatment would have the following effects. Streams and rivers within the Three Rivers Watershed would be affected by changes in hydrology, removal of domestic and industrial wastes and channel modifications. Waterways within land treatment areas of North Central Ohio would be affected by increased discharge, change in chemical composition, and channel

modifications. The magnitude of these effects would vary from plan to plan.

Land treatment sites within the Three Rivers Watershed and sites in North Central Ohio are primarily agricultural lands. Changes in agricultural patterns and farm management practices would be required under certain wastewater treatment alternatives. Soil texture, structure, fertility, and biota also would be affected. Stripmined areas in Southeastern Ohio would require specialized land management practices under some plans.

Lake Erie would be affected by changes in the chemical composition of the tributary water. This would include reduction in the quantity of plant nutrient such as phosphates and nitrates entering the lake. Some elements such as sodium and chlorides might increase. The quantity of sediments entering the lake also would vary depending upon the wastewater treatment plan adopted. The total quantity of water entering Lake Erie would remain relatively unchanged regardless of the plan adopted, but the quantity of water entering particular points along the lake shore would be changed in some cases.

2. Ecological and Other Environmental Factors

a. Energetics

(1) Which technology consumes the least amount of irreplaceable natural resources such as fuels, chemical coagulants, electrolytes, and organic compounds?

Water Based Wastewater Treatment (WBWT) alternatives require quantities of irreplaceable natural resources in the form of coal (electricity), steel, concrete, alum, lime, polymer, salt, and car-

bon to remove residuals from wastewater. All technologies require structural materials for pipelines, pumping stations, and waste treatment facilities. The environmental impact on ecosystems that supply these natural resources may exceed the impact of untreated wastewater in the Three Rivers Watershed.

NOTE: In recent testimony before the House Committee on Public Works, Dr. Joseph T. Ling, Director of Environmental Engineering and Pollution Control Department of Minnesota Mining and Manufacturing Company (3M Co.) presented approximate costs in terms of natural resources required to achieve complete removal of the annual quantity of wastes from a typical 3M plant (Ling, 1972).

To obtain water of drinking water quality, Ling estimated that 4000 tons of pollutants must be removed annually. The removal of these wastes would require 9000 tons of chemicals, 1500 kilowatts of electricity, and 19,000 tons of coal in addition to the steel, concrete, and power required to build a suitable treatment facility.

The treatment process would generate 9,000 tons of chemical sludge and 1200 tons of fly ash, all of which must be disposed of in some manner. Production of the treatment chemicals would require 15,000 tons of natural resources and generate 6,500 tons of sludge wastes. The generation of 1500 kilowatts of electricity would require 6000 tons of coal, and leave 470 tons of fly ash and 100 million BTU's of waste heat.

Ling concludes that the environmental impact of wastes generated in obtaining and refining natural resources for the construction and operation of wastewater treatment facilities may greatly exceed the impact of the untreated wastewater.

The waste removal process illustrated by Ling would involve methods similar to those proposed for WBWT plans. Although the actual costs of WBWT facilities and operations in the Three Rivers Watershed will vary somewhat from the costs proposed by Ling, his conclusion that current methods of WBWT would have an overall negative environmental impact appears valid.

The maximum Importance Value of 10 has been assigned to this parameter because of the undesirable effects of continued resource

utilization predicted by the recent Club of Rome Project on the <u>Predicament of Mankind</u> (Meadows et.al., 1972).

NOTE: This study has been widely acknowledged as the most comprehensive and reliable effort to date to model growth in the world system. Five basic factors, including population, capital, food, nonrenewable resources, and pollution were modeled under a variety of possible management alternatives for the world system. A standard world model was run that assumed no major changes in the physical, economic, or social relationships that have historically governed the development of the world. In addition to the standard world model individual models were tested that assumed a doubling of natural resource reserves, the introduction of "unlimited" nuclear power, pollution controls, "perfect" birth control, and various combinations of possible management practices. The results of all of these models indicate an alarmingly rapid decline in nonrenewable resources despite the introduction of individual and combinations of management procedures into the models. The rate of decline varies from model to model, but in all cases the decline can be described as very rapid and presents mankind with very serious problems.

The daily consumption of chemicals for each wastewater management alternative has been used as a criterion for rating this parameter.

Chemical Consumption (#/day x 1000)	Value
0-200	3
200-400	2
400-600	1

The Land Based Wastewater Treatment (LBWT) alternatives and combination land based and water based (combination plans) treatment alternatives rate highest in this category. Physical-chemical water based wastewater treatment facilities consume the largest quantities of chemicals and have been given the lowest possible

rating. Biological water based facilities consume moderate quantities of chemicals and usually have been assigned an intermediate rating.

(2) Which plan requires the least electrical power annually?

Electrical power requirements for each wastewater alternative must be carefully evaluated from the ecological viewpoint as well as the economic point of view. The present cost of electricity for the basin does not adequately reflect the environmental costs of electrical power production.

In the Three River Watershed, electrical power is supplied from fossil fueled steam electric power stations. This method of production probably will continue through the year 2020 before significant quantities of electrical energy are produced for the watershed by other means. Environmental costs of producing electricity in a steam electric power station include: (1) expending an irreplaceable natural resource; (2) exposure of miners to "black lung" respiratory disease in underground mines; (3) sulfuric acid water pollution, erosion, and destruction of terrestrial ecosystems in strip mining; (4) runoff pollution from coal piles in storage; (5) wasted heat to air through the stacks; (6) contamination of air with sulfur oxides, nitrogen oxides, and particulates; (7) ash, clinkers, and other residue from the combustion process; (8) contamination of cooling water with biocides used for slime control; (9) approximately one half of the heat produced by combustion dissipated to cooling water; (10) heat damage to aquatic life passing through turbine cooling systems; and (11) land use for transmission lines (Abrahamson, 1970).

Although most of these environmental costs will be incurred outside of the Three Rivers Watershed, compensatory charges must be included for electrical power used within the basin.

A monetary value for many of the environmental costs listed above is difficult, if not impossible, to establish. Methods for establishing compensatory charges for environmental damage remains one of the most formidable problems facing pollution abatement programs. Despite these short-comings, due consideration must be accorded to the environmental costs of electrical power required for each wastewater treatment alternative.

The consumption of electrical energy is such an important environmental problem that the maximum Importance Value of 10 has been assigned to this parameter. The daily consumption of electricity for each wastewater management alternative has been used as a criterion for rating the ecological impact.

Electrical Consumption megawatts	Value
3000-4000	3
4000-5000	2
5000-6000	1

The WBWT plans and combination plans that emphasize water based treatment consume the least electricity. These plans have been assigned the highest magnitude values. All land based plans that emphasize land based treatment consume the largest quantities of electricity and have been assigned the lowest magnitude values.

(3) Which technology contributes most toward achieving a P/R = 1 ratio for impacted ecosystems?

(4) Which technology best promotes the development of complex, weblike food chains?

Production/respiration ratios of unity and complex weblike food chains are most characteristic of mature, stable, "protective-type" ecosystems. Heavily managed agricultural ecosystems and ecosystems receiving domestic and industrial wastes deviate significantly from P/R = 1 ratios and are characterized by short, simple food chains. The implication of questions 3 and 4 for the Three Rivers Watershed apply mostly to aquatic ecosystems within the basin and to Lake Erie. These ecosystems should be maintained as near to natural conditions as possible. Natural species successional patterns should be encouraged and the need for continual outside maintenance should be minimized.

Terrestrial ecosystems in North Central Ohio and Southeastern Ohio as well as aquatic ecosystems in North Central Ohio will require sustained outside maintenance. In the case of agricultural ecosystems, the P/R ratio will be deliberately maintained greater than unity through energy supplements in the form of labor, and the consumption of fuels, pesticides, and herbicides. Because of this requirement for outside management, terrestrial ecosystems in North Central Ohio, Southeastern Ohio, and aquatic ecosystems in North Central Ohio have not been included in the evaluation of environmental impact on P/R ratios or the development of food chains.

The quantity of phosphates discharged to waterways under each wastewater management alternative has been selected as the best single index of the ecological impact on P/R ratios and food chains. Phosphates discharged to waterways usually stimulate the growth of

aquatic plants so that an imbalance between production and respiration is created. These imbalances often lead to violent oscillations between excessive production of organic matter and increased microbial respiration of the accumulated organic materials. Overproduction of aquatic plants clogs waterways, increases the turbidity of the water, and creates nuisance odors and tastes. Decomposition of the accumulated materials often leads to oxygen depletions and to undesirable species changes in aquatic communities.

An Importance Value of 5 has been assigned to question number 3 and a value of 1 assigned to question number 4. Magnitude Values have been assigned according to the following criteria.

Phosphate Discharged to Waterways Tons/Year	Value
0-100	3
100-200	2
200-300	1

The smallest quantities of phosphates are discharged to waterways under all LBWT plans. Combination plans with emphasis on land treatment discharge moderate quantities of phosphates while WBWT alternatives release the largest quantities of phosphates.

(5) Which technology maximizes the return of humic materials to ecosystems of origin?

From the ecological viewpoint, incineration of sludge as proposed in some plans is an extremely poor alternative. In undisturbed ecosystems, compounds similar to those contained in organic sludges are stored within the system in the form of humus. In terrestrial ecosystems, humic compounds help build soils and improve the hydroscopic capacity of soils. They also provide a suitable

substrata for rooted vascular plants including all agricultural crops. The combination of humus, weathered bedrock, and soil biota prevents excessive leaching of the mineral nutrients from the soil. Mineral cycles are thus closed and the nutrient exchange rate between organisms and the environment is slowed. The net result is a stable system that is well protected from physical disturbances.

Sludge resembles natural humic compounds in many respects. Sludge contains a high percentage of organic material, increases the soil moisture holding capacity and the total nitrogen content, and it improves soil aggregation. It is particularly effective in restoring soils that have been badly eroded or stripped of organic matter.

In view of these potentially beneficial properties of sludge, the burning of this material is particularly inadvisable. Considerable acreage within the watershed as well as thousands of acres of stripmined land just south of the basin would benefit immeasurably from sludge enrichment.

Burning of sludge not only destroys a valuable resource, but additional resources are required to achieve complete and efficient combustion. Incinerators equipped with modern pollution control devices will be required. In addition, natural gas already in short supply within the basin, will be required for sludge drying and combustion. The consumption of an irreplaceable natural resource for the destruction of a potentially beneficial product is particularly unwise from the ecological viewpoint.

An Importance Value of 5 has been assigned to methods employed for returning humic materials to the ecosystem of origin. Magnitude Values have been assigned on the following basis:

	Value
-Humic materials returned to origin (All land-based plans)	3
-Combination plans without incineration & AWT with sludge disposal	2
-Humic materials sent elsewhere (Combination plans with incineration)	1

(6) Which technology requires the least expenditure of human labor and fossil fuels (energy supplements) to maintain stability in agricultural, aquatic, and terrestrial ecosystems? Or which technology supports the largest biomass per unit of energy flow?

Some wastewater management alternatives solve waste disposal problems in one ecosystem, but create problems in other systems. For example, the removal of domestic and industrial wastes from aquatic ecosystems within the Three Rivers Watershed should have beneficial effects on these areas. But the disposal of these wastes on land areas will require elaborate irrigation equipment, storage areas, underdrains, and continual management of the disposal system. From the ecosystem viewpoint, a large amount of supplemental energy will be required to maintain stability in ecosystems receiving wastes from other regions.

An Importance Value of 10 has been assigned to this parameter. Magnitude Values have been assigned according to the following criteria:

	Value
-Easily maintained ecosystems (AWT alternatives)	3
-Combination plans with in-basin land treatment	2
-Ecosystems unstable and maintainance difficult or costly (ALT plans and combination plans with land treatment in North Central/ Ohio)	1

b. Community Structure

(7) Which technology maximizes for diversity of aquatic life within the limits imposed by natural substrates?

(8) Which technology best contributes to the development of stratification and highly organized communities of plants and animals?

(9) Which technology best encourages species with narrow ranges of tolerance to environmental factors?

Questions 7, 8, and 9, apply primarily to aquatic ecosystems because the removal of present waste loads from these systems will allow the development of natural biotic communities. Because of the need for special management practices in land treatment areas natural communities will not develop in most terrestrial ecosystems.

An Importance Value of 10 has been assigned to question number 7, a value of 1 to question number 8, and a value 1 to question number 9. Criteria for rating the Magnitude Value are based on the level of waste treatment achieved under each wastewater management alternative. Level One refers to the State of Ohio effluent quality standards; Level Two is based upon the national goal of the elimination of the discharge of pollutants into navi-

gable waterways and relates to technical goals established by the Chief of Engineers, Department of the Army, commensurate with that goal.

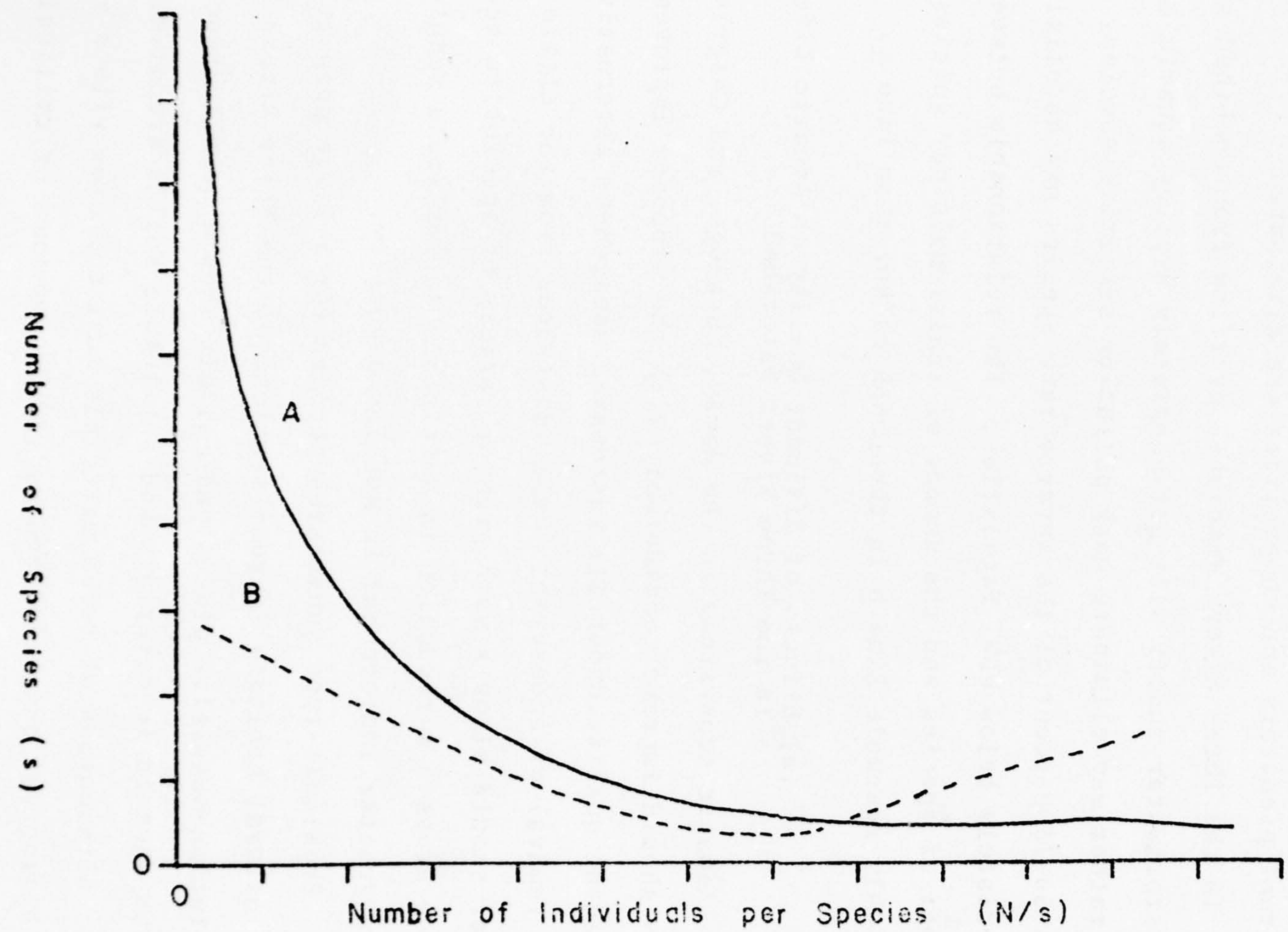
The effects of differences between the two standards probably will be most noticeable in the structure of aquatic communities. The level of stormwater treatment is considered in this rating criterion because the ecological effects of stormwater also will be most apparent in parameters of community structure.

	Value
-Maximize diversity of aquatic life (Level Two effluent standards and Level Two stormwater treatment)	3
-Level Two effluent standards and secondary treatment of stormwater	2
-Minimize diversity (Level One effluent standards and Level One stormwater treatment)	1

Natural aquatic communities in undisturbed streams usually contain a great variety of distinctive kinds of organisms. A typical clean-water aquatic community contains (1) a large number of species (kinds of organisms) represented by only a few individuals per species, and (2) a few species with a large number of individuals per species. This is illustrated in Figure 4 where the number of species is plotted against the number of individuals per species. Line a shows the relationship for a normal, healthy, clean-water community. The hypothetical effect of some pollutant on the community is shown in line b.

Species are progressively eliminated as the environmental stress increases. Highly sensitive species are eliminated first,

Figure 1. General relationship between the number of species (s) and the number of individuals per species (N/S) for a natural community (A) and a polluted community (B).*



*(After E. P. Odum, 1971. Fundamentals of Ecology, Saunders Company.)

followed by the more tolerant varieties until all species are eliminated under severely toxic conditions. In the special case of organic pollution and in the absence of toxic substances, certain tolerant species may increase dramatically in abundance as their less tolerant predators and competitors are eliminated.

In the Three Rivers Watershed overflow from combined sewers and stormwater runoff will not completely destroy aquatic communities but rather may eliminate many pollution-sensitive species. Perhaps 50-75 percent of the invertebrate species may be eliminated immediately below WBWT facilities. The relationship between the number of species and the number of individuals per species would probably resemble line b in the graph rather than line a.

(a) Effects of Effluent Quality on Aquatic Life in the Three Rivers Watershed

Aquatic ecosystems in the Rocky, Cuyahoga, and Chagrin Rivers should improve considerably with the proposed improvement in effluent quality under all wastewater management alternatives. The removal of industrial toxic substances from the Little Cuyahoga River should allow a much greater variety of species to occupy these areas. A reduction in settleable solids would result in an even greater improvement in species diversity.

Erosional-type substrates account for a large proportion of the natural habitats in most sections of the Three Rivers Watershed. Pollution-sensitive plants and animals should quickly reoccupy these areas once toxic materials and settleable solids are eliminated.

Elimination of toxic materials must coincide with a reduction of biological oxygen-demanding (BOD) compounds or critical low

levels of dissolved oxygen will spread to other sections of the river. Currently, toxic wastes inhibit the maximum possible effects of BOD in the middle and lower Cuyahoga River. In a similar manner, toxic materials presently inhibit the growth-stimulating potential of phosphates and nitrates on river plant life.

Highly organized communities of plants and animals, including many species with narrow ranges of tolerance to certain environmental factors will develop rapidly under each plan. All plans probably will promote the development of more complex and weblike aquatic food chains in the lower Rocky River, middle and lower Cuyahoga River, and the lower Chagrin River. A greater variety of producers, consumers, and decomposers should return to many waterways as BOD levels, organic sediments, and toxic materials are reduced or eliminated. Short linear food chains involving untreated and partially treated organic wastes, sludge worms, midges, and bacteria will diminish as longer, more complex food webs involving algae, aquatic insects, vertebrates, and bacteria increase in importance.

All plans should increase the variety of ecological niches, encourage populations of larger organisms, and assist species with long, complex life cycles. Large insects with complete metamorphosis should return to many areas of the middle and lower Cuyahoga River, lower Rocky River and the lower Chagrin River. Larger species of fish including many game fish varieties also should return to these areas.

Most plans also will enhance "feedback-type" of population control for nuisance organisms such as mosquitoes, midges, leeches, and sludgeworms. Biological control of pathogenic organisms also will be improved.

(b) Effects on the Biota of the Sandusky River

The biota of the Sandusky River (and other streams in North Central Ohio) will be greatly affected by the increased flow of water from land treatment areas. The greatest effects on aquatic life will occur as a result of changes in the bottom habitats. Alteration of flow regimes will drastically change the distribution of substrate materials and the normal fluctuation in water level. River substrates play a dominant role in the species composition and the distributional patterns of all aquatic life. All major photosynthetic organisms and invertebrate consumers are influenced by the nature of the bottom materials. Fish and other aquatic vertebrates either directly or indirectly depend upon bottom organisms for food. Substrates also play an important role in the incubation of fish eggs.

The major change that is anticipated in the river bottom will be an increase in finely textured depositional substrates and a decrease in coarsely-grained, erosional-type substrates. Pooled areas and deep runs will increase at the expense of shallow, high velocity riffle areas.

Well documented studies covering the past 60-70 years, have shown that riffle areas contain the greatest variety of bottom-dwelling plants and animals. These areas supply large quantities of

food to fish and other consumers occupying the deeper, pool and run areas. Elimination of riffle areas from streams in the western Ohio land treatment region will greatly reduce these highly productive aquatic habitats.

The magnitude of the runoff should be decreased as much as possible by buffer zones of grasses, shrubs, and woodland between the treated agricultural lands and the receiving streams. These zones will reduce runoff by increasing evapo-transpiration and by increasing percolation rates to the ground water.

The number of riffles eliminated from the Sandusky River and other streams in the region that may be affected cannot be determined without (1) more detailed information on the precise location of land treatment areas; (2) the present number of permanent riffles; (3) the size of buffer zones; and (4) the quantity of effluent applied. The maximum potential wastewater return flow to the Sandusky, Huron, and Vermilion Rivers is estimated to double the annual average flow of these rivers. (Wright-McLaughlin Engineers, Surface Hydrology Supplement to Phase 1 Report on Land Treatment Considerations under Contract No. DACN 49-72-C-0051). Because of the low gradient in each of these rivers, over 90 percent of the permanent riffle areas probably would be eliminated.

Biological diversity in the Sandusky, Huron, and Vermilion Rivers and their tributaries probably will decline under LBWT Plans. The increased flow of water in these streams will reduce the variety of habitats, thereby restricting the diversity of aquatic life even though the chemical and physical properties of the water

may be optimal. Uniform substrates also will restrict the development of highly organized aquatic communities and encourage only those species with a wide range of tolerance to environmental factors.

Aquatic food chains within the land treatment area also may be shortened and simplified as a result of increased water flows. A reduction in the variety of substrates will lead to a more uniform community of organisms and, hence, to shorter and less complex food chains than presently exist in these streams.

The variety of ecological niches also may be reduced in the Sandusky River because of increased substrate uniformity. Biological control of nuisance organisms and pathogenic organisms probably will not be enhanced under LBWT Plans, but control of these organisms should be adequate.

What effects will these changes in bottom habitat and water depth cause in the aquatic communities? A reduction will most likely occur in the proportion of animals characteristic of eroding substrates such as mayflies, stoneflies, fishflies, alderflies, caddisflies, and certain beetles. Some species of molluscs, and fish, particularly darters, suckers, and minnows also would be reduced. Animals such as aquatic earthworms, leeches, chironomids, dragonflies, damselflies, certain beetles, and aquatic bugs will undoubtedly increase. If the sediments contain large proportions of organic materials, some populations of these latter organisms may reach nuisance proportions. Fish such as bluegills, bass, carp, and catfish probably will increase.

Aquatic plant life will change from sessile species adapted to shallow, fast-moving water to species better adapted to deeper, slower-moving, more turbid water. Filamentous green algae and diatoms characteristic of eroding substrates will be replaced by rooted aquatic vascular plants and planktonic algae species.

(10) Which plan maximizes biotic storage of major plant nutrients?

An Importance Value of 1 has been assigned to this parameter. A discussion of the ecological implications of the biotic storage of major plant nutrients has been given above. Criteria for rating this parameter are based on the quantity of phosphates discharged to waterways under each wastewater management plan. Land-based wastewater treatment alternatives and combination plans discharge the smallest quantities of phosphates and have been assigned the highest magnitude values.

Phosphates Discharged Tons/Year	Value
0-100	3
100-200	2
200-300	1

c. Nutrient Cycling

(11) Which technology maximizes recycling of phosphorus and nitrogen?

(12) Which technology maximizes biological control of nutrient cycles?

An Importance Value of 10 has been assigned to question number 11, and a value of 1 to question number 12. Criteria for rating these parameters are based on the quantity of phosphates discharged annually to waterways. The quantity of total nitrogen discharged

also may be used as a criterion for rating each technology. Nitrogen, however, has not been included because the quantities discharged are proportional to the quantities of phosphates discharged under each wastewater management plan.

Land based wastewater management alternatives maximize the recycling of phosphorus and nitrogen and maximize biological control of nutrient cycles. These plans have been assigned the highest magnitude values for the above parameter.

With WBWT plans, phosphorus is precipitated and either wasted in a land fill or spread over land where it is of limited agricultural value because of its relative insolubility and combination with other chemicals. In LBWT methods, phosphorus is utilized quickly and efficiently in plant growth. Biological control can be maintained through immediate harvest and reuse at a later time. Retention of phosphorus in soils and its rapid uptake by plants prevents leaching of significant quantities into ground water.

In natural ecosystems phosphorus is slowly leached from terrestrial regions into oceanic sediments. Significant quantities of phosphorus are returned to land only in certain island and coastal areas where food chains consisting of bottom feeding animals, phytoplankton, fish, and birds exist. Man has greatly accelerated the loss of phosphorus to oceanic sediments through destruction of terrestrial vegetation cover and misuse of phosphate rock extracted for agricultural, domestic and industrial purposes.

Recycling of phosphorus is especially important at this time in view of the rapid depletion of the world's phosphate reserves. Large quantities of phosphorus are required to maintain current

levels of agricultural productivity. Recovery of phosphorus from domestic and industrial wastes will become increasingly important as the current supplies of phosphate fertilizers dwindle and become more expensive. The LBWT alternative can most effectively achieve this objective.

Nitrogen in WBWT alternatives is released to the atmosphere where it has a negligible effect on the ecosystem. Although the effects on the environment are minimal, the loss of nitrogen works counter to agricultural needs for nitrogen fertilizers. Considerable energy and natural resources are expended for nitrogen enrichment in most agricultural systems. Nitrogen in the form of nitrates and ammonia are applied in large quantities to the soil to maintain high levels of agricultural productivity. Recycling of nitrogen by land treatment methods should greatly reduce the need for nitrogen fertilizers and maximize biological control over the flow of this element.

One of the most serious disadvantages of WBWT alternatives for nitrogen disposal is the requirement for electrical power and chemical additives. Acquisition of electrical power and chemical additives represents a considerable environmental impact at some point in the biosphere. Although electrical power is required for LBWT alternatives, no chemical additives or treatment facilities are required. Nitrogen, rather than wasted to the atmosphere, is recycled into organic nitrogen.

(13) Which technology maximizes reuse of organic sludges as soil conditioners?

(14) Which technology generates least inorganic sludges or sludges with very poor reuse potential?

An Importance Value of 5 has been assigned to this parameter. Magnitude Values are based on the daily consumption of chemicals because the quantity of inorganic sludges generated is directly perportional to the quantity of chemicals used.

Chemicals (#/day x 1000)	Value
0-200	3
200-400	2
400-600	1

Inorganic sludges resulting from WBWT have little or no value as soils conditioners or fertilizers unless reprocessed. Disposal of these sludges presents an added cost with no ecological benefits and create more environmental damage. Reprocessing of sludges would require additional natural resources and create more environmental damage.

(15) Which technology least disturbs natural hydrologic regimes?

(16) Which technology least threatens the quality of ground water supplies?

(17) Which technology best retards leaching of plant nutrients into ground water?

An Importance Value of 10 has been assigned to number 15, a value of 5 to number 16, and a value of 5 to number 17. Magnitude Values are based on the extent to which natural hydrologic regimes are altered by each of the wastewater management plans. Currently 85% of the water used within the Three Rivers Watershed is withdrawn from Lake Erie. Most of this water either is returned directly to Lake Erie or discharged into tributaries within a few miles of the lake. Very little water withdrawn from Lake Erie comes in con-

tact with land areas within the Three Rivers Watershed. This greatly reduces the chances of contaminating ground water supplies and has little effect on the leaking of plant nutrients from top soils.

Approximately 11% of the water used within the Three Rivers Watershed is withdrawn from the upper Cuyahoga by the City of Akron. Most of this supply is returned to the Cuyahoga River below Akron. Although the normal river flow is disrupted between the point of withdrawal and the point of reentry, negligible amounts of the Akron water supply come in contact with land areas. For this reason, neither the quality of ground water nor the leaching of plant nutrients is threatened by this source.

	Value
-Least hydrologic disturbance (water based wastewater treatment)	3
-Combination plans with in-basin land treatment	2
-Most disturbance (land based wastewater treatment & combinations plans with land treatment in NC Ohio)	1

(a) Ecological Impact of Proposed Changes in Hydrologic Regimes

Ecological changes resulting from changes in hydrologic regimes are difficult to predict. Regionalization of sewage treatment facilities will create low flows in portions of the Rocky River, Tinkers Creek and several other small streams within the basin. As much as 50 percent of the critical low-flow of the lower Rocky River and Tinkers Creek is now augmented by wastewater. Water for waste disposal, and for domestic and industrial uses is presently

supplied to this region from Lake Erie via the City of Cleveland. Diversion of this Lake Erie water from Rocky River and Tinker's Creek should return the "natural" flow to these streams, however, residents of these areas may be displeased with the natural flows because adequate control of the natural regimes has been lost in recent years through increased urbanization and accompanying decreases in protective vegetation. The net effects of this loss in control will result in more frequent oscillations between flooding and droughts.

The effects of both flooding and droughts on aquatic life are unpredictable (Hynes, 1970). Both the frequency of occurrence and the magnitude of the events determine the effects on aquatic life. Many species of benthic animals important in aquatic food chains require periods of low-flow to complete their life cycles. Some caddisflies, for example, emerge into adult reproductive stages during low-flows. Complete dessication of the stream bed, of course, will interfere with reproductive activities of this organism and may destroy the population.

Flooding destroys aquatic habitats through erosion and sedimentation. Organisms not adapted to depositional substrates are eliminated from heavily sedimented regions. If significant quantities of organic materials with high BOD are washed into the streams, oxygen depletions may destroy large segments of the aquatic community. Several months following a flood may be required to re-establish the normal aquatic life.

(b) Effects of Changes in Hydrologic Regimes Within the Three Rivers Watershed

The transfer of wastewater to farmlands of North Central Ohio will have considerable ecological impact on the middle and lower sections of the Cuyahoga River. Akron withdraws approximately 50 MGD of water from the upper Cuyahoga River for domestic and industrial uses. Most of this water plus additions from local ground water and industrial supplies is returned to the middle Cuyahoga River below Akron. Withdrawal of water from the river at Lake Rockwell creates critical low-flows at certain times between the points of discharge and withdrawal. At the point of discharge the stream flow is restored and slightly augmented with partially treated wastewater.

Neither a LBWT nor an WBWT alternative would change the hydrologic regime between Lake Rockwell and the Akron wastewater treatment facility as long as Akron continues to withdraw water from Lake Rockwell. A land treatment alternative for Akron, however, would remove considerable quantities (as much as 60%) of water from the lower Cuyahoga River. Water loss of this magnitude could seriously affect large segments of aquatic life in this region.

The hydrologic regime in the Cuyahoga River could be improved greatly by supplying Akron with water from Lake Erie. The return wastewater then could be transported out of the basin without disrupting the normal river flow below Akron. Normal flows could then be restored between Lake Rockwell and Akron.

(c) Effects of Changes in Hydrologic Regimes in Streams Draining Land Area

The increased flow of water in the Sandusky, Huron, and Vermilion Rivers will greatly increase the rate of transport of sediments into Lake Erie. The relationship between suspended load of a river and discharge may be defined by the expression:

$$G = pQ^j$$

where G is the sediment load and p and j are constants (Leopold, et. al., 1964). Values for j usually range from 2 to 3. Assuming that discharge doubles at the mouth of the Sandusky River, (Wright-McLaughlin, 1972) the sediment load to Lake Erie will increase approximately 4 times.

The increased transport of sediments to Lake Erie from the Sandusky, Huron, and Vermilion Rivers will not be compensated by a reduction in sediment transport to Lake Erie from the Cuyahoga, Rocky, and Chagrin Rivers. Although the discharge to Lake Erie from the Three Rivers Watershed will be decreased by an amount approximately equal to the increased discharge from the Sandusky, Huron and Vermilion Rivers, the quantity of sediments transported will differ considerably. The reason for this is that in the Three Rivers Watershed, most of the water transported to Western Ohio farmlands will be supplied from Lake Erie through the city of Cleveland's water supply system. Under WBWT plans, wastewater is returned directly to Lake Erie or discharged to the lower reaches of the Three Rivers, usually within a few miles of Lake Erie. Negligible amounts of this water will contact upland soils and contribute significantly to soil erosion. Under LBWT plans, most water

supplied from Lake Erie will be transported to Western Ohio farmlands and discharged in headwater areas. Here the contact between water and upland soils will be greatly increased. The potential for increased soil erosion will increase accordingly.

The impact of this increased sediment load in Lake Erie cannot be adequately assessed at present. Compared to the suspended sediments carried into Lake Erie by other streams and rivers, the projected load increase from the Sandusky, Huron, and Vermilion Rivers is infinitesimally small. The additive effects of numerous small sediment loads on Lake Erie, however, may be considerable.

The most serious effects probably will be greater turbidity, increased rate of sedimentation, destruction of spawning grounds of desirable fish species, nutrient enrichment of aquatic plants, and a reduction in variety of pollution sensitive bottom-dwelling organisms. The magnitude of these effects depends upon the contribution of sediments from other sources, seasonal variations, and the nature of the sediments.

d. Life History

(18) Which technology contributes most to the development of a great variety of ecological niches?

(19) Which technology best encourages populations of large organisms?

(20) Which technology best encourages species with long, complex life cycles?

e. Selection Pressure

(21) Which technology is most compatible with a "feedback control" type population growth forms?

The rationale for establishing Importance Values and Magnitude Values based on the levels of wastewater and stormwater treatment for parameter numbers 18, 19, 20, and 21 is similar to that described above under Community Structure. The development of a great variety of ecological niches, populations of large organisms, species with long, complex life cycles and "feedback-type" population growth forms is influenced, for the most part, by the same environmental factors that affect the structure and organization of aquatic communities.

(22) Which technology best enhances control of nuisance organisms such as mosquitoes, house flies, midges, leeches, sludgeworms, aquatic weeds, and bluegreen algae?

An Importance Value of 5 has been assigned to this parameter. Magnitude Values are based on the extent to which ponds, lagoons, and open water storage areas are required for each wastewater treatment plan. Water-based plans require the least impounding of water in open areas and have been assigned the highest magnitude values.

	Value
-Least impounding of open water (water based wastewater treatment)	3
-Combination plans with in-basin land treatment	2
-Most impounding (land based wastewater treatment and combination plans with land treatment in North Central Ohio)	1

(23) Which alternative best promotes control of pathogenic organisms including certain bacteria, viruses, and "swimmers itch"?

(a) Effects of Combined Sewer Overflows on Aquatic Life

Although aquatic community-energetics, community-structure, nutrient cycling, life history, selection pressure, and overall homeostasis will be greatly improved under most WBWT alternatives, the magnitude of these improvements may be less than would be possible under LBWT plans. Limited improvement in aquatic life may be noted in sections of the Cuyahoga River below wastewater treatment facilities at Akron and Cleveland southerly, because of periodic overflows from combined sewers.

At least one overflow per year can be expected from WBWT facilities designed for the one-year storm. The magnitude of this overflow probably will equal or exceed the overflow expected from the hypothetical 2.5-year storm.

Because of these periodic overflows bacterial counts below WBWT facilities may exceed the State of Ohio water quality standards in many areas. Beaches may have to be closed occasionally. The danger of viral infections and other water-borne diseases also will increase because of periodic overflows.

The effects of these overflows on other aquatic life are difficult to predict at the present time. Because of the diverse nature of aquatic life, an overflow will affect each species in a different manner. The response of each organism will depend upon the stage in the life cycle, the nutritional status, and the relative abundance of each species. The magnitude, frequency, and chemical characteristics of the overflow will greatly influence the nature and magnitude of the effects on aquatic life. In addi-

tion, the effect of an overflow can be different at different seasons.

Land-based wastewater management plans offer the best protection against the spread of pathogenic organisms. Magnitude Values have been assigned according to the following criteria.

	Value
-Most control of pathogenic organisms (land based treatment & combination plans with land treatment in North Central Ohio)	3
-Combination plans with in-basin land treatment	2
-Least control (water based wastewater treatment)	1

f. Overall Homeostasis

(24) Which technology *maximizes mutualistic or synergistic* relationship among living organisms?

(25) Which technology interferes least with the natural successional development of ecosystems?

For criteria used to rate Magnitude Values for questions 24 and 25, see Community Structure parameter number 7 above.

(26) Which technology best promotes the rehabilitation of destroyed or badly disturbed terrestrial ecosystems (stripmined lands, for example)?

A maximum Magnitude Value of 3 has been assigned to wastewater management plans which include methods for sludge disposal on stripmined lands of Southeast Ohio. No other plans include provisions for the rehabilitation of stripmined lands.

(27) Which alternative in case of mechanical failure provides maximum protection for aquatic ecosystems?

The wastewater management alternatives rate evenly on this parameter.

(28) Which technology generates the least quantity of potentially harmful biological and chemical aerosols?

The generation of potentially harmful biological and chemical aerosols does not appear to be a major environmental problem with any of the wastewater management alternatives.

(29) Which technology requires the least disturbance or destruction of terrestrial ecosystems (land-use) for pipelines, sewers, and structural facilities?

Land requirements vary considerably for the various wastewater alternatives. Magnitude values have been assigned according to the acreages of land required, excluding land needed for spray irrigation and sludge disposal

Land Required-Acres	Value
0-50	3
50-100	2
100-+	1

(30) Which technology requires the least conversion of terrestrial ecosystems into aquatic systems?

Most land-based wastewater treatment plans require extensive winter storage reservoirs. Considerable land also will be required for aerated lagoons and stormwater holding ponds under some plans. In many cases prime agricultural lands will be converted to aquatic ecosystems. The loss of crop production from these lands probably will not be compensated by increased production on adjacent irrigated croplands. Water based wastewater treatment plans require the least conversion of terrestrial to aquatic ecosystems.

Magnitude Values have been assigned to each technology according to the following criteria:

	Value
-Least conversions of terrestrial to aquatic ecosystems (all water-based treatment plans	3
-Combination plans	2
-Most conversion (land-based treatment)	1

(31) Which technology best protects plant, animal, and human life from possible cumulative toxic effects of heavy metals or other harmful industrial and agricultural chemicals?

The disposal on land wastes containing heavy metals such as Ag, Al, Cd, Cr, Cu, Fe, Mn, Ni, Pb, Su, and Zn presents several problems of considerable environmental importance. First, will the soils and vegetation effectively remove or reduce the concentration of each of these elements to safe levels in the drainage water from land disposal areas? Secondly, how will various agricultural crops such as wheat, alfalfa, corn, and soybeans respond to repeated applications of wastes containing heavy metals? Will any of these elements reach toxic levels for certain crops? Thirdly, what will be the long-term effect of heavy metal accumulation through food chains into terminal consumer organisms?

Research related to these problems is extensive and no attempt will be made here to review the thousands of articles on this subject. The results usually are controversial and are hotly debated.

In general answers are best established for the first question raised regarding the effectiveness of soils and vegetation in removing heavy metals and other harmful chemicals from domestic and industrial wastewater. According to a recent review of this sub-

ject it appears that many soils and crops are extremely effective in removing toxic and harmful chemicals as well as plant nutrients from domestic and industrial wastewaters (Cold Regions Research and Engineering Lab, 1972). Continuous management of all phases of the land treatment process, however, is essential to achieve adequate removal of all undesirable chemical components and to prevent contamination of the surface waterway and the local ground water supplies.

The second question noted above regarding the effect on crops of repeated applications of wastes containing heavy metals and other harmful chemicals also has been the subject of hundreds of research studies. Although much controversy surrounds this topic, most evidence indicates that the common agricultural crops grown in Ohio can tolerate extremely large concentrations of heavy metals when applied to the land from sewage sludges and secondary effluent. Again careful and continuous management of all phases of the waste application procedures is required for effective results.

Very little research has been performed regarding the third question; the long-term effect of heavy metal accumulation through terrestrial food chains into terminal consumer organisms. Recent experience with heavy metal accumulation such as mercury and lead in aquatic food chains indicates that food chain accumulation may be a serious problem in agricultural and natural terrestrial food chains.

The ecological and environmental factors discussed above, are presented in tabular form (Table 42) in the Summary Section following page 380.

C. SUMMARY OF IMPACTS OF LAND-DISCHARGE AND WATER-DISCHARGE WASTEWATER TREATMENT TECHNOLOGIES

The following two tables condense and summarize the material presented above on the ecological and other environmental considerations of the two major treatment technologies considered in this study. Water-discharge technology consists of both biological and physical-chemical processes, and different combinations of these can be utilized to reach tertiary treatment levels. The environmental impacts differ somewhat according to the particular combination. More specific details are given in the plan-by-plan evaluations.

Table 39

SUMMARY OF MAJOR IMPACTS OF LAND DISCHARGE
WASTEWATER TREATMENT TECHNOLOGY OPTIONS
(Relative to water discharge treatment option)

	Impact usually not desirable	Impact usually desirable
1.		Lower natural resource consumption rates in treatment processes.
2.	Higher electricity consumption in effluent transfer.	
3.		Nutrients and humic materials released to crops and woodland through irrigation; nutrients recycled in productive ways and under control.
4.	Produces unstable, simple ecosystems; if used for agriculture; maintenance more difficult and costly.	
5.	Possible and likely hydrologic disturbances.	
6.	Interbasin transfers of water required; with major impact on lower Cuyahoga River.	
7.	Increases sediment transfer into Lake Erie.	
8.	Possible nuisance organism problems due to open, impounded water.	
9.		Stabilizes aquatic ecosystems within Three Rivers Watersheds.
10.		Stabilizes control of pathogenic organisms through control of combined sewer/storm water overflows.
11.	Terrestrial ecosystems (farmland) converted to aquatic ecosystems (lagoons, holding ponds, etc.).	
12.		Stabilizes control of accumulation & disposal of heavy metals and other possible toxic industrial and agricultural chemicals.
13.		Promotes complex food chains.
14.		Promotes complex communities of organisms.
15.		Potential for reclaiming wasted land.
16.		Relative mechanical reliability.

Table 40

SUMMARY OF MAJOR IMPACTS OF WATER-DISCHARGE WASTEWATER TREATMENT TECHNOLOGY OPTIONS
(Relative to land discharge treatment option)

	Impact usually not desirable	Impact usually desirable
1.	Higher natural resource consumption rates in treatment process; (particularly physical-chemical process.	
2.		Lower electricity consumption.
3.	Nutrients released into aquatic ecosystems, landfills, atmosphere. Disposal of humic materials a problem. Nutrient recycling not under control.	
4.		Produces complex and diverse aquatic ecosystms, easily maintained (under normal conditions).
5.		Less hydrologic disturbance.
6.		No interbasin transfers of water.
7.		No sediment increase.
8.		Nuisance organism control.
9.	Oscillations in aquatic ecosystems due to periodic combined sewer/storm overflows.	
10.	Varying control of pathogenic organisms.	
11.		Balance between terrestrial and aquatic ecosystems maintained.
12.	Uncontrolled dispersion and dilution of heavy metals, other chemicals.	
13.		Promotes complex food chains.
14.		Promotes complex communities of organ sm
15.		Potential for reclaiming wasted lands.
16.		Relative mechanical reliability.

D. COMPONENT ANALYSIS AND IMPACT

The above discussion of the strengths and weaknesses of the treatment technologies under consideration (necessarily limited to ecological impacts) provides a necessary preparation for the more detailed evaluation to follow of the individual plans. Ease of understanding is also facilitated by understanding of the components and processes of wastewater management. The management system can be separated for analytical purposes into these subsystems: Sources, Collection, Treatment, Residuals and Disposal. After brief remarks on each subsystem a summary table relating components, impacts and design alternatives is presented.

1. Systemic Components

a. Sources

The complexity of wastewater management is rapidly accelerating as additional inputs for treatment are being added. These include industrial wastes, urban and non-urban run-off and increasing quantities of cooling water in addition to traditional domestic wastes. The following comments on non-urban runoff are illustrative of the ramifications of wastewater sources.

(1) The Effects of Non-urban Runoff and Urban Stormwater

Evidence from a limited number of studies in the upper Chagrin River and the upper Cuyahoga River indicates that non-urban runoff causes considerable degradation of aquatic communities. Since non-urban runoff is not to be treated under any wastewater treatment alternative, damage to aquatic life as a result of this runoff will not be prevented. None of the wastewater alternatives

can be expected to improve aquatic life conditions above the levels imposed by non-urban runoff.

The constituents of non-urban runoff most damaging to aquatic life in the Three Rivers Watershed include inorganic and organic soil sediments and organic effluent from septic tank drainage. Soil sediments originate from the extensive land-clearing that has taken place within the watershed for domestic, industrial and agricultural purposes. Less than one percent of the climax deciduous forest remains in the watershed. Even second growth woodlands cover less than 20 percent of the watershed.

The best means for retaining stormwater is to restore the deciduous forests which once covered most of the Three Rivers Watershed. In Northeast Ohio the deciduous forest is the most effective mechanism for intercepting rainwater and for controlling its flow to either ground water or to surface waterways. Dramatic increases in runoff as a result of clearing forested areas has been demonstrated in a number of watershed studies. Shrubs and other perennial plants, while more effective than annual crops in controlling runoff, are much less effective than deciduous trees. Swamps and lakes also effectively control runoff but have a limited life span. Cropland and impervious areas such as roofs, paved roadways, and parking areas provide very little control over stormwater runoff.

Since this study is considered to be a passive, long-range effort, more attention should be given to possible educational, social, and political means for achieving at least partial restoration of an effective vegetative cover. Residents of the

watershed should not be led to believe that they can continue to clear and pave land with impunity.

An extensive reforestation program and careful land management practices will be required to prevent further siltation. Regulations requiring periodic pumping of septic tanks should be implemented to prevent effluent from entering the streams. Because of the large volume of non-urban runoff, the adoption of no-discharge standards for the treatment of domestic wastes and urban runoff is a highly desirable goal if the impact on Lake Erie is to be minimized.

Although a reforestation program should be implemented, the loss of runoff control already is so severe that a ponding program for urban runoff is the only immediate solution. The program should be regarded however, as a "stop gap" measure at best.

Numerous small ponds located in headwater areas would appear to be sound management from the ecological viewpoint. Retention of water in ponds should increase the percolation rate into ground water and allow time for advanced treatment. The net loss of land to ponding (approximately 2000 acres) might not exceed the acreage recovered from swamps over the past 100 years.

The effects of periods of high water on benthic invertebrates have been documented in numerous studies (Hynes, 1970). In most cases the variety and abundance of organisms is greatly reduced by flooding. This reduction can be caused by direct washout of organisms, displacement of bottom sediments, suffocation in sediments, or suffocation as result of dissolved oxygen deficiencies. Occasionally toxic substances reduce or eliminate aquatic life during a period of high water. A general conclusion that Hynes

(1970) draws from studies of the effects of high water on invertebrates is that streams subjected to frequent natural flooding have fewer species of aquatic life than others. In most cases where man has increased the intensity of run-off or caused habitat changes, the variety and abundance of stream life also has been reduced.

Based on these conclusions, stormwater overflows in the Three Rivers Watershed probably cause similar reductions in variety and abundance of aquatic life. The magnitude of these changes cannot be accurately predicted at this time.

b. Collection

Collection difficulties increase as we move toward total treatment and recycling of all surface waters. In particular, collection and treatment of stormwater will be a costly requirement under the new Federal water quality standards.

c. Treatment

Refinements in treatment technology and stricter controls over effluent quality and disposal are posing problems of serious magnitude to the public sectors of our society. Industrial waste treatment is a major problem in our region, as the following remarks illustrate.

(1) Collection and Treatment of Industrial Wastes

Collection and proper treatment of industrial wastes is extremely crucial to the restoration of the middle and lower reaches of the Cuyahoga River and is necessary to reduce significantly the impact of the river's water on Lake Erie. Industrial waste volumes equal domestic waste volumes in the Three Rivers Watershed.

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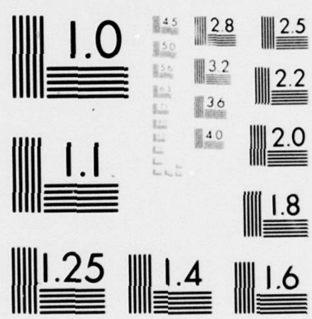

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Industrial wastes and urban runoff all but eliminate aquatic life in the lower sections of the Little Cuyahoga and in the Cuyahoga River between the Little Cuyahoga and the Akron WTP. Industrial wastes and urban runoff also adversely effect aquatic life and create public health hazards in the lower section of the river through Cleveland. Little change in aquatic life can be expected in these regions as a result of any wastewater disposal plan unless industrial wastes are eliminated. Increased DO in the river as a result of BOD removed from wastewater and urban storm water runoff will have little beneficial effect upon aquatic life as long as toxic materials are present.

Under certain wastewater management alternatives considerable treatment of industrial wastes will be required at each industrial plant. If each industry is required to develop adequate treatment facilities, the consumption of natural resources required for building and operating the facility will probably create greater environmental damage than the damage resulting from untreated wastes. A more detailed description of this ecological impact has been given above under the "Consumption of Irreplaceable Natural Resources."

The evaluation of wastewater treatment plans in relation to this parameter depends to a large extent upon the effectiveness of the day-to-day waste treatment operations. With each facility operating effectively, there would be very little difference in the effectiveness of alternatives. Because of the doubt surrounding the effect of heavy metals accumulation in agricultural and natural terrestrial food chains, the land-based alternatives are least

desirable. If LBWT plans are used for the rehabilitation of strip-mined land, rather than for the fertilization and irrigation of cropland, then land-based plans with aerated lagoons and untreated industrial wastes would be highly acceptable.

We assume that all noncompatible industrial wastes will be removed from WBWT plans and LBWT plans where secondary effluents without sludge are used for irrigating croplands.

d. Residuals

Part of the cost of getting clean water is the generation of waste materials of many sorts. For example, land discharge to farmlands requires the construction of a tunnel to western Ohio. No major ecological impacts are foreseen in the construction of a tunnel to the western lands treatment sites. One important advantage of tunneling is that terrestrial ecosystems will suffer minimum disturbances. This feature is especially important in Ohio where considerable acreage of prime agricultural and recreational lands has been utilized for highways, electrical power lines, and oil and gas pipelines.

The depth of the tunnel is great enough that neither the flow nor quality of ground water should be impaired. Ground water yields in the region traversed by the tunnel are relatively large.

Disposal of rock tailings from the tunnel during construction should not pose major problems. These materials might be used to halt erosion along the Lake Erie shoreline, used for diking lake frontage in metropolitan areas, or placed in stripmined lands. The effects of the rock tailings on Lake Erie probably would be less than the effects of shoreline sediments presently eroding into

the lake. Stripmined areas would not be improved with the addition of tailings, but certainly no additional damage could be done to these areas. The rehabilitation of stripmined lands would be impeded, but the ecological magnitude of this impact would be small compared to the overall task of strip mine restoration.

e. Disposal

What to do with the large quantities of clean water, waste materials and by-products of wastewater treatment without wasting valuable resources or dirtying other aspects of our environments is a major problem. For example, secondary level effluent contains large and valuable quantities of plant nutrients. To dispose of this effluent in our lakes causes problems; to dispose of it on farmland produces a benefit and can make the farmland part of the treatment process itself. The effects of secondary effluent on cropland are reasonably well documented. The results of numerous studies have been summarized recently by the U.S. Corps of Engineers, Cold Regions Research and Engineering Laboratory (1972).

The principal conclusions drawn in these studies are as follows:

1. If effluents are properly applied to suitable soils 95-99+ percent of the BOD, COD, P, metals, suspended solids, and pathogens can be effectively removed from the effluent. Nitrogen is removed less efficiently--85+ percent removal.
2. Drainage water of drinking water quality is obtained from properly treated land.
3. The detrimental effects of wastewater residuals on cropland is minimal even when large doses of heavy metals are applied.

4. The land must be carefully managed to achieve optimum crop responses, adequate removal of residuals, and minimum loss of soil particles.

5. Leaching rates of certain elements from treated soils are greatly increased, but the added wastewater residuals usually more than compensate for the loss to leaching processes.

6. Productivity of most crops is greatly accelerated.

The most important ecological implications of these findings are as follows:

The return of undigested organic materials (BOD), plant nutrients (nitrogen and phosphorus), trace elements (metals), pathogens, and saprophytic micro-organisms to upper soil horizons closely parallels the flow of these materials in natural terrestrial ecosystems. In mature terrestrial ecosystems most undigested and unrespired organic matter is deposited on the soil where microbial activity further reduces the material to its elemental constituents. Relatively small quantities of terrestrial organic matter is deposited in waterways of undisturbed ecosystems.

Most of the organic material contained in domestic wastes from the Three Rivers Watershed comes from agricultural areas outside of the watershed. The precise origin and quantity of these imported materials is known only in a general way.

Because of the uncertainties of origin and the impracticality of returning residuals to their precise area of origin, the best alternative is to return the materials to the nearest agricultural lands outside the watershed.

2. Impacted Areas and Design Alternatives Affected

Table 41 shows the impact areas and the design alternatives affected by changes imposed in management systems as a function of variations in the elements of each particular system component.

Table 41

WASTEWATER MANAGEMENT COMPONENTS,
SIGNIFICANT IMPACT AREAS, AND DESIGN EFFECTS

SOURCES	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Industrial	In-plant treatment will be mandatory Segregation of industrial waste required Pollution control costs will be imposed Potential changes in the industrial process May affect industrial composition by forcing transfer or closing of marginal industry	Institutional: will require regulatory controls, monitoring, and penalties, cost of government Economic: AWT costs in-plant of both equipment and operation. Economic-Ecological: Forced reuse of water, change of technology to use less water. Economic-Ecological: Cost and drain on other resources. Economic-Social: Loss of employment due to marginal industry loss. May have minor offset due to professionals required to operate AWT.	All plans will be affected equally by changes in the quantity and quality of wastes coming into the system.
Domestic	Population may vary considerably from that expected due to changes in birth rate, migration, etc. resulting in lower water use. Per capita use may respond to user charges Sewer systems may expand in relation to stricter land use controls in development tighter restrictions on leaching beds Mandatory annual septic tank cleaning	Social - demographic effects Economic: cost factors in water use Institutional: will require increased government land controls, uniformity on a regional basis. Institutional	
Urban run-off	An increase in urbanization and density will result in greater imperviousness Relative importance of urban run-off pollution will increase as other sources controlled	Ecological-Economic Ecological	
Non-urban run-off	Will increase in relative importance as other sources are controlled Requirements for non-structural control: upstream ponding, construction restrictions, agricultural control, flood plain regulation, slope regulation, reforestation	Ecological Institutional - social constraints	
Cooling Water	Response to temperature limitations will create opportunity for alternate cooling methods, water re-use, etc.	Economic-Ecological: Cost of cooling by alternate methods, recycling of wastewater, effect on treatment process	
General	All plans will be affected by changes in volume, changes in quantity and character of pollutants, and changes in present and future water use and re-use.		

COLLECTION	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Industrial	Direct discharge to streams is not contemplated for future - compatible waste will be discharged to sewer systems Requirement for sewer interconnection	Economic-Institutional; requirement for controls, sewer construction, connections	All plans
Domestic	Upgrading of collection system-sizing Requirement for major interceptors	Economic: cost Economic-Institutional-Social: Land use, pipeline easements, cost of land, dislocations of people.	Based on extent of regionalization
	Interconnection of present sewer plants	Economic-Institutional: Cost, System re-use, public attitudes	
Urban run-off	Requirement for collection establishment of large numbers of collection-sedimentation basins	Institutional-Social: Legislative action, land use - major acreage required. Public health: safety factor, attractive nuisance, insect habitat Aesthetic: question of multiple use, intermittent mud flat, odors	All plans
	Diversion from direct stream return Removal of urban pollutants Prevention of flood conditions	Ecological: maintenance of stream flow Public health: lessening disease factors Ecological-economic	
Non-urban run-off	*Non-structural changes*	Institutional	All plans
Cooling water	Will require collection rather than release to receiving waters in order to cool	Economic	All plans
TREATMENT			
Domestic/Industrial - Land	Philosphy of waste treatment	Institutional-Social: requires a change of public and political attitudes	All land based plans
	Institutional changes required to organize, finance, build and operate the system	Institutional: Local government vs regional; special purpose districts	All land based plans with more difficulty facing extra-basin plans
	Intergovernmental relations	Institutional: Intra and inter basin relationships with no present focus	"
	Legislative requirements	Institutional: Action of state legislature required for authority	"
	Tax base may be reduced in areas where extensive land is taken for government ownership and use	Institutional: Community finances	"

TREATMENT	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Domestic/Industrial - Land	Property values may be reduced in close proximity to land treatment sites	Aesthetic-Institutional-Economic	"
	Changes in land use	Economic-Aesthetic-Social: Effect on community and region	
	Land ownership, potential relocation of population from land treatment areas	Social-Economic: community and resident disruption	Greater on land used in basin
	Major transmission costs for the effluent tunnels, distribution systems	Economic: Land use, easements	Plans based on use of western lands
	Irrigation	Ecological-Public Health: Wetter ecosystem, animal habitat, insect potential, concentration of harmful constituents by evaporation, aerosols	
	Under-drainage	Economic-Ecological: Cost and effect on water table	"
	Discharge areas-post treatment	Ecological-Economic: Effect on stream flow, flood potential	"
	Soil conditions and biota	Ecological: build-up of constituents in soil, effect of effluent on biota, effect on life of soil filter	"
	Ground water changes in quality, quantity	Ecological-Public Health: Effects of by-pass to ground water, acquifers	"
	Agricultural restrictions, changes	Economic-Public Health: Mandatory crop requirements, changes in present crop patterns, marketing, plant restrictions based on health question	"
	Interbasin water transfer	Ecological: Stream flow in Three Rivers watershed	Plans using land out of basin
	Interjurisdictional waste transfer, requirement for in-basin treatment if out of basin to be possible	Institutional-Aesthetic: Public-political perceptions	
	Secondary vs untreated effluent to be sent for aerated lagoon treatment in west	Economic-Institutional-Aesthetic: Public-political perceptions, question of "waste" of current and planned secondary capacity in basin	Plan transmitting untreated effluent
	Land improvement, retention of open space	Ecological-Institutional-Aesthetic: upgrading of marginal lands, maintenance of open space, beautification	All land use plans
	Environmental disruption	Ecological-Social-Aesthetic: Changes in ecology, disruption during the construction phases	"
	Winter storage basins	Social-Aesthetic-Public Health: The requirement of major land use, plus an aerobic conditions generating odors	"
	Wild life habitats	Ecological-Public Health: establishment of habitats for water based birds animals, possible disease hosts	"
	Automatic Level TWO process is inherent in land treatment methods	Economic-Public Health: no need to go in stages to attain no discharge level immediate benefit to public health, lower cost factors.	"

TREATMENT	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Advanced Waste Treatment - Water Based	Institutional changes required to organize, build, finance and operate the system	Institutional: local government vs regional, special purpose districts	All regional plans
	Intergovernmental relations	Institutional: Intra-basin relations, possible focus in 3 Rivers district, new regional (sub) organization	"
	Legislative requirements	Institutional: Legislative action may be required for authority	"
	Reduction of tax base, reduction in property values in proximity to treatment plants, land use changes, population dislocation may occur but in a lesser degree than land based treatment	Institutional, Aesthetic-Social-Economic	"
	Capital cost factors in AWT	Economic:	"
	Discharge areas - post treatment	Ecological-Economic: effect on stream flow, flood potential	"
	Power requirements imposed by AWT	Economic-Ecological: Cost and other resource areas affected, air pollution increment	All water based plans
	Chemical resource input required for AWT	Economic-Ecological: Cost and other resource areas affected	
	Magnification of residuals, *2 - 4 X*	*Economic-Ecological: Disposal* problems	"
	Question of reliability of AWT plants in terms of peak versus average capability, plant failure, process failure, redundancy requirements	Economic-Ecological-Public Health: Effect of failure on water, health and cost involved in prevention	"
	Flexibility in relation to changes in new technology, incorporation as developed, increase or decrease due to changes in population, water use		
	Requirements for plant in changing from Level ONE to level TWO	Economic: capital and operating costs	"
	Changes in chemical quality of receiving waters as a result of the several advanced waste treatment procedures - dissolved solids	Ecological-Public Health: Limits to buffering capacity of receiving waters	
	Plant Life - effective life of AWT plants as opposed to land treatment methods	Economic: replacement factors	"
Stormwater	Prevention of overflows in combined sewers, relationship to resewering, interception in areas already storm sewered	Economic-Public Health: Cost of stormwater collection, storage, treatment; public health cost in allowing overflow.	"
	Collection-sedimentation ponds for 162 basins	Institutional-Economic-Public Health: large land requirement in basin, public safety, mud flat residuals	All plans

TREATMENT	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Stormwater	Vast increase in treatment requirement, operation, maintenance	Economic: capital and operational costs	All Plans
	Effect of dilution on biological treatment	Economic: plant size requirements, effect on reliability of treatment	Level TWO water based plans
	Effect on stream flows, discharge points	Ecological: Effect on stream flow flooding potential	Variable, but more negative in highly regionalized plans
Cooling Water	Installation of cooling systems	Economic: cost of plant, operation	Should be of concern to all plans
	Incentive for installation of descending water re-use plans, other water re-use opportunities	Economic: cost factors in re-use, reduction in volume of water use, wastewater	
RESIDUALS			
Land Treatment Effluent	Improved water quality with associated effects on receiving waters	Ecological, public health, social, aesthetic, economic: indirect effects in all areas	All land based plans
Advanced Waste Treatment Effluent	Same as above	Same as above	
Secondary Sludges	Increased volumes from the establishment of secondary treatment for all wastes	Economic: storage, disposal requirements	All plans
	Winter storage residuals	Economic: requirement for dredging and disposal	Land based plans
	Stormwater sediments	Economic: requirements for dredging and disposal	All plans
	Concentration of pathogens, metals	Public health: requirements for handling and disposal	All plans
Tertiary Sludges	Major increase in quantity	Economic-Ecological: additional handling, disposal problems	All water based plans
	Low organic, largely chemical sludges	Same as above	"
	Brine residuals from AWT	Same as above	"
	Re-use, recycling potential	Economic: cost of treatment chemicals, other utility	"
Gaseous Residuals	Possible nuisance odors from winter storage, irrigation practices, treatment plants, stormwater basins	Aesthetic: community problem and response	Variable to all plans
	Process residuals - ie: ammonia stripping	As above	Water based plans

DISPOSAL	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Sludges: Incinceration of Secondary	Increase in quantity from regional operation	Economic: Cost of incineration	All plans using incineration
	Major increase in air pollution	Economic-ecological: requirement for installation of pollution controls, resources cost	"
	Loss of resources represented in the nutrient and other characteristics for soil rehabilitation, other purposes	Ecological-Economic: Economic and resource loss	"
	Input of power, fuel requirements for dewatering, drying, incineration	Economic-Ecological: Cost and resource factors	"
	Transmission requirements where regionalization of incineration plants is specified	Economic: Cost factors	"
	Land fill requirements for disposal of ash in face of limited basin areas available	Institutional-Economic: Land use	"
	Potential pollution of ground water from land fill disposal of ash	Public Health-Ecological: Chemical and metal constituents	"
	Hazards of volatilization of mercury and other metals	Public Health: health hazard	"
Strip Mine	Transportation of sludges, requirements of application, management of area	Economic-Institutional: Long term management problem	Plans using strip mine disposal
	Removal of water from basin	Ecological-Institutional: Water used in transportation of sludges may reduce flow in minor way; potential violation of Lake compact.	"
	Rehabilitation of destroyed land	Ecological-Economic: Improvement of land now useless for any purpose	"
	Potential effects on ground water in area, stream quality	Ecological: acid neutralization	"
		Public Health: concentrated metals, pathogens in sludges may leach	"
Land Application	Transportation of sludges, requirements of application, management of area, new agricultural equipment	Economic-Institutional: cost factors, requirements for management	Plans using land application
Agricultural Products From Sludge or Effluent Application	Specific crop requirements resulting in management and marketing problems	Economic-Social: farming patterns, volume effect on marketing, surplus, pattern of farm life	Land Based Plans
	Question of plant up-take of specific contaminants, crop choice, biomagnification	Public Health: Utility of produce	"
	Public attitudes toward crops - acceptance edibility	Social-Aesthetic: disposal problems	

DISPOSAL	CHANGES IMPOSED	IMPACT AREA	PLANS CONCERNED
Industrial sludges Other tertiary and Chemical Sludges	Constitutes a collection problem from thousands of dispersed industries	Economic-Institutional: cost and need for public operation, management	All plans for industry and water based plans for other tertiary sludges
	Concentration of toxicants	Public Health: hazards	"
	Problems of concentration, dewatering	Economic: plant cost factors	"
	Major increase in brines	Economic-Ecological: disposal problems	"
	Problems of recovery, re-use	Economic-Ecological: *potential for* recovery of valuable materials, cost of recovery, lessened hazard to the environment	"
	Ultimate disposal problems	Economic-Ecological-Public Health: Is ultimate disposal possible without effect on other sections of the total ecology; is there any utility to the tertiary sludges produced by AWT? Questions of where and how in the Three Rivers Basin area.	"

VII. EVALUATION OF ALTERNATIVE REGIONAL WASTEWATER TREATMENT SYSTEMS (TWELVE PLANS)

A. Introduction

The methodology of assessing the full range of impacts of the twelve alternative plans, has encompassed a review of hundreds of potential relationships, both positive and negative, in the areas of ecological, public health, institutional, social, economic and esthetic changes that might result from a particular plan or treatment method. The importance of such changes vary from insignificance to ones of major concern. The display of such extended detail could well obscure the intent and conclusions of the evaluation.

At the request of the Ohio Department of Natural Resources, a more concise evaluation was developed, one that would characterize each plan and enable a selection of those plans or plan components which could then be carried forward in time and cost phasing and greater detail. The following plan evaluations use eleven major evaluation categories, as outlined in Section B following. The categories represent a distillation of the range of parameters detailed in the section on Methodology. The evaluation group is concerned that the essential detail not be submerged, and reference is made to these multiple criteria, which should be considered in concert with the plan by plan review. (See Methodology page 11.)

The evaluators attempted consistently to derive the initial effects from process components for several reasons. First because this is where primary effects arise; lack of effectiveness or process failure may compromise the entire system and initiate a chain of unforseen events. Secondly, data on facility reliability was requested by the

State of Ohio. Thirdly, the Interim Report of the Secretary of the Army, speaking on the results of the feasibility studies, noted that further investigation was required regarding the effectiveness and reliability of the technology for both water and land disposal. The report went on to say that further study of treatment effectiveness was "critical since the overall treatment processes proposed in these studies have never been utilized on a large scale in major urban areas where there is a wide and fluctuating range of domestic, commercial and industrial waste generated."

The evaluation, then, has attempted to derive future effects of the proposed technology and development, based on the conditions of the area as far as they could be established and with due regard for the uncertainities that are inevitable in any project with an extended time horizon.

B. Major Evaluation Categories

1. Ecological Considerations

The assessment of the several wastewater management systems for the Three Rivers Basin[1] should be based on structural and functional characteristics of mature, stable and healthy ecosystems. The ecosystem is the basic functional unit in ecology, enabling a systematic study of the complex inter-relationship between living organisms and the physical environment. For convenience in applying ecosystem parameters, the area of concern may be divided into terrestrial and aquatic ecosystems, each including an aerial zone and a soil and sub-surface zone. Detailed consideration was applied to both the aquatic environment and the land affected in the Three Rivers Basin, the specific agricultural areas of North Central Ohio, the strip mined areas of Eastern and Southeastern Ohio, and Lake Erie. The attributes used to characterize the degree of stability, maturity or health of the ecosystem are indicated under the categories of Energetics, Community Structure, Nutrient Cycling, Life History (of aquatic ecosystems only) Selection Pressure (also aquatic), and Overall Homeostasis. These specific characteristics are defined in the Section on Methodology. In some instances, more detailed consideration is given to specific ecological factors, which necessarily involve the greater environment, in other sections of this evaluation.

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[1] The combined basins of the Rocky, Cuyahoga and Chagrin Rivers and certain minor streams tributary to Lake Erie.

2. Resource Demands

This section is responsive to the growing concern for the conservation of non-replaceable resources, and the consumption of power, fuel and the various chemical participants in the treatment of wastewater. Also considered are the resources within the wastewater and the secondary products in soil, vegetation and agriculture that may be fostered. The cost of clean water locally must be interrelated to the use of major resources, their potential availability and alternate uses, and the creation of equal or greater pollution within the basin, or elsewhere, in the product of the energy and the resources used. Policy planning will necessarily consider the wider implications and priorities in this area.

3. Reliability

The reliability factor combines a range of consideration applicable to all components of the system, from collection through disposal. Both system and process elements are reviewed to consider whether a plan can achieve a postulated effluent level 365 days a year, the protection afforded the ecosystem in case of failure and the potential for alternate and protective systems. Plants, processes and transmission elements are subject to biological, chemical and mechanical failure, as well as deficiencies caused by human error and administrative inadequacy. Potential exists for the loss and transfer of pollutants, the creation of nuisances and the release and/or concentration of health hazards.

The inadequacies and causes of failure in standard processes are known and can be compensated for, but little information is available on the effectiveness of innovative treatment designs. In this case,

the process elements and the environment surrounding them and in which they operate are reviewed to determine, by analogy or otherwise, the stress points, the type of inter-relationship, the uncertainties in short or long term operation and the elements at hazard, such as ground water, soil biota or viruses in the carbon absorption process. In some instances, the best that can be determined will be the need for specific research, monitoring, or a demonstration program.

4. Land Use Changes

The consequences of planning a wastewater management system, or any other water resource development, may affect the future by influencing public and private decisions on the location and timing of other development, on the use of available land and other resources, and on the management of services and utilities. Planning for wastewater management is necessarily multi-purpose planning, and cannot be confined from its influence over other areas of decision making, such as the location and use of land for thermal power plants that use water for cooling or the close coordination with planning for land uses to be served by the project.

Among the most important challenges to planners are those associated with local uses of water and land, water supply and wastewater management for metropolitan areas, and the management and use of water for local commerce, domestic use, recreation and public health. Land use planning must be integrated with water resources planning to obviate the mutual constraints that may otherwise be generated. Without denying the importance of water resources planning, it is only one aspect of overall resources planning to satisfy human wants.

The land requirements of the several plans are projected against a growing public unease over urban encroachment, unregulated development, and the paving of prime farm lands. In the discussion of land required for wastewater management, the possibility of concomitant public uses such as open space preservation, flood control, environmental protection, recreational potential, or agricultural benefits are introduced. More detailed land use planning is required.

Each plan will require significant amounts of land for the collection, storage, transmission and treatment of stormwater and domestic wastes. All plans contemplate such land use controls as are needed to curb urban runoff and other non-discrete sources. Land treatment will require the long term commitment of major acreage, either through public ownership or under contract. Property values, land ownership, the tax base, and community life may be affected. Land irrigation and winter storage of effluents may create changes in the ecosystem, in soil conditions or utility, in crops, in ground water, and in various biota including wildlife, plants and insects. The alteration of the land may have both conservational and detrimental impacts and will in any event require a continuing management.

5. <u>Public/Political Perceptions</u>

This section of the evaluation comprehends a host of social and institutional parameters characterized in the way that political/ administrative persons and jurisdictions perceive their role and self-interest, and the way in which the general public--either as

individuals, families or communities--view the changes proposed. Political feasibility and institutional resistance or accommodation are major considerations that will dictate whether a watershed plan becomes a reality or remains as a sterile recommendation. Thus the evaluation considers the constraints of existing institutional arrangements, the diffuse organizational system with their multiple preconditioned viewpoints, the lack of coordinated and harmonious goals across the areas concerned, and the constraints to public participation in planning. Intergovernmental relationships, both within the basin and interbasin, now either non-existent or tenuous, are further exposed to the hurdles of/intervasin transmission of treated or untreated sewage, an urban-rural conflict over the transfer of a metropolitan problem, and the necessity for devising and establishing an administrative structure capable of financing, constructing and operating a system, monitoring and regulating discharges, and providing the professional manpower requirements.

In addition, an attempt is made to evaluate the plan's impact on the public's perception relating to what is essentially a change in the philosophy of waste treatment, to socio-economic effects such as changes in employment opportunity, home and community dislocations, changes in individual property values, and in the community tax base, and finally esthetic reactions to alteration of the physical landscape and the acceptance of technological and institutional innovation.

6. Economic Considerations

No attempt is made to duplicate in this analysis the cost factors displayed in other appendices. Caution is recommended, however, in applying a straight cost analysis based only on preliminary capital and operation and maintenance costs. Among the significant direct costs will be the comparative plant life in the different processes.

Cost optimization has not been driven to a point to preclude innovative variations in transmission, treatment or reuse potential. Therefore all individual plans cannot be directly compared.

The indirect economic factors cannot be ignored. The cost difference to industry between a system that can accept process wastes and one that cannot may be indicated in its relationship to the regional economy. The synergistic offset available in the potential for water reuse, as in power plant cooling or industrial processing is not quantified, nor is the effect of assured flood control, stream augmentation, or agricultural returns.

Consideration must be given to the financing arrangements in the new legislation, and this is treated separately in attachment D. The major land plans which require heavy front-end capital costs and relatively minor operations and maintenance costs (O & M), contrast with the water based plans requiring smaller capital outlays and heavier O & M costs. The significance of major long-term changes in the pricing structure of treatment chemicals cannot be overlooked since the cost structure of the plans would suffer major changes. In essence, the evaluation of costs must be undertaken in a larger context than sewage treatment.

7. Flexibility

The concept of consideration of alternative futures in the planning process is an emerging one. The many futures that can be hypothesized for this area encompass such things as policy choices, socio-economic phenomena and life styles, physical phenomena and technological development. By proper planning, the future that will ultimately emerge can at least be influenced.

Planning has rarely taken alternative futures into account. Commonly, forecasts have been made of specific water uses (wastewater volumes) and specific plans made to meet these uses. However, there can never be a final solution to a water resource problem, and planning must be a continuing series of adjustments to changing conditions. Planners should recommend only short-term commitment of resources to the maximum feasible degree, and retain as many long-term options as possible.

In exploring alternative futures, both needs and opportunities should be considered. "Needs" are essentially forecasts based on projections of past trends in population distribution and economic growth. In an absolute sense, however, there are few immutable needs for water and by extension, for wastewater. Perhaps the most prominent and indispensable are water requirements for drinking and for firefighting. All else will be responsive in some degree to policy, price or human environmental changes. Opportunities, then, are departures from the projection of past trends to correct imbalances and take advantage of changing situations. Current technology, population, waste flows and pollution control objectives must obviously be used as a base. But, while specific changes may be impossible to predict, change itself is inevitable. It is essential, therefore, that each plan permit a maximum of adaptability to change in the phasing and structure, both plan and plant.

8. <u>Stormwater Management</u>

The introduction of stormwater treatment into the framework of wastewater management represents a significant departure from traditional practice and requires separate consideration. The

effects that derive from the collection and treatment of stormwater vary with the level and method of approach. Consideration is given to the effectiveness of the plan in controlling stormwater pollution from separate and combined sewers and in non-sewered areas, the relationship of stormwater treatment to the requirements of sanitary and industrial sewage treatment, and the comparative impact of stormwater pollution in relation to the design storm level.

9. Hydrologic Effects

Proposed changes in the collection and treatment of stormwater runoff, the prevention of sewage overflows, the diversion and transmission of wastewater, the regionalization of treatment and disposal, and in some instances, the interbasin transfer of water, will have an effect on the current (which may or may not be the natural) hydrologic regime of the Three Rivers and of certain streams and rivers in North Central Ohio. Among the effects considered will be those on stream flow, on aquatic habitats and biota, on erosion and the transport and deposition of sedimentation, on flood control, water supply requirements and sources, as well as the potential for multi-purpose use.

10. Residuals

In the treatment and rehabilitation of wastewater, pollutants of various types are removed and retained for disposal. Depending on treatment methods, additional residuals are produced such as gases, dissolved solids, algae and various chemical sludges. Certain costs, requirements and/or opportunities may be generated by the philosophy of disposal. The major residual will be an

effluent of varying quality depending on the process and the level of the treatment applied. The effect of effluent quality is considered as well as opportunities for recycling and re-use.

11. Disposal Methods

The improvement of wastewater treatment cannot change the fundamental law of the conservation of matter. Although the potential exists in industrial waste treatment to recapture some of the waste as a valuable by-product, most pollution control will involve the removal of pollutants from the wastewater. Disposal of these residues has been increasingly recognized as a problem with serious environmental impacts.

Various environmental costs and management requirements will be generated by the selection of disposal methods including power, fuel, transmission, air pollution controls, and land for fill or for surface application. The potential exists for either continued wastage or for recycling of the resources in waste and for beneficial and rehabilitative land uses. Conversely, a potential also exists for transfer of pollution to ground or surface water, to air, or to soil and crops in the use/disposal of residuals, Extended and appropriate management may be necessary in the solution of the problems developed by such end products as controlled agricultural products, industrial sludges, and brines.

C. INDIVIDUAL PLAN EVALUATION

1. Plan 1, Level One, Water Disposal

a. General Features

The Northeast Ohio Water Development Plan forms the basis for Plan 1, upgraded to meet Level One effluent criteria rather than stream quality standards, and to provide for collection and treatment of urban storm runoff. Domestic and compatible industrial wastes will be collected in sanitary systems, given tertiary treatment, with the effluent released to the rivers and to Lake Erie. All of the flow in combined sewers will be treated as if it were sanitary only. Stormwater in separate sewers will be collected and treated locally in sedimentation basins, with microstraining and chlorination before discharge to streams.

Plant Configuration	No.	Type[1]	SWTP[2]	Acreage in Basin
Rocky River	2	AWT	26	118
Chagrin River	7	AWT	30	68
Cuyahoga River	12	AWT	68	226
Lake Erie	5	AWT	12	153
Total	26		136	565

(1) Sludge Disposal

Holding, concentration, incineration and disposal to landfill 100%

(2) Facilities Required

In accordance with the Northeast Ohio Water Development Plan, construction of a southwest interceptor is planned, to collect all

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[1]AWT - Advanced Waste Treatment (Tertiary)

[2]SWTP - Stormwater Treatment Plant

of the sanitary sewage from the East Branch of the Rocky River and the West Branch from Liverpool to North Olmsted. Transmission will be to the Cleveland Southerly plant. Only Liverpool on the West Branch and Lakewood on the Lower River will maintain discharges to the Rocky River, while about 40 mgd will be diverted. Eleven current plants will be phased out. Stormwater management will require upstream ponding and overflow control, with treatment in storage/sedimentation basins sized for one year storms and requiring a 6-day release period. The projected 11,110 acre feet of storage would require from 600 to 1,000 acres depending on the depth of the basins.

(3) Special Features

Treatment facilities for domestic/industrial wastes are highly regionalized in the Rocky River Basin. Separate stormwater runoff will be treated in the basin of origin and will interfere only marginally with the low flow of the Rocky River Branches.

b. Ecological Considerations

The discussion of the ecological impacts of the several plans must be related on a comparative basis. Any statement made that a particular plan is the "least" or "most" responsive in any particular characteristic will be relative. Thus two plans using a single disposal method may both rate high (or low) for the method. At the same time, plans using more than one method (combination plans) may rate a moderate designation for a characteristic. Because of the variable ecosystem impacts from a single aspect of one plan to the next, no one plan can be the best or worst in toto, and any relative plan assessment may be made only by accumulation. This will be true of other factors discussed, as well as ecology.

(1) Community Energetics

Plan 1 requres the input of relatively large amounts of outside resources and power for its operation, does not contribute to a stable P/R ratio (the ratio of gross production to total community respiration is probably one of the best functional indexes of the relative maturity and stability of the ecosystem), does not promote complex food chains and does not return humic materials to the ecosystem of origin. The best that can be stated about its energy consumption is that it requires the least human effort and resource input in the management of its residuals.

(2) Community Structure

The plan provides the least encouragement to the diversity of aquatic life, to highly organized communities, or to species narrowly tolerant of change, all normally evident in a stable ecosystem. The plan minimizes the biotic storage of plant nutrients.

(3) Nutrient Cycling

The plan makes no provision for recycling of nitrogen or phosphorus, destroys the organic sludges, minimizes biological control of nutrient cycles and generates chemical sludges with poor reuse potential. However, it does not threaten the quality of groundwater supplies except by leaching of the incinerator ash in landfill and it will have only a moderate effect on "natural" hydrologic regimes.

(4) Life History

Niche specialization, a larger size of organism and longer, complex life cycles are characteristic of mature aquatic ecosystems. This plan will provide the least encouragement of this area.

(5) Selection Pressure

This plan will be more compatible with feedback control of population growth forms and the control of nuisance organisms such as insects and aquatic weeds. It will have the least effect on the control of pathogens in the water.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist the disruption of outside disturbances. Plan 1 provides least encouragement to organism interrelationships, interferes more with natural ecosystem succession development and does nothing to promote terrestrial ecosystem rehabilitation (strip mined areas, for instance). It has the potential for major discharge of potentially harmful chemical aerosols. It requires the least disturbance of terrestrial ecosystems or interconversion of land to aquatic ecosystems, but must be downgraded on its comparative protection of plant, animal and human life from potential cumulative effects of toxic metals and other chemicals.

c. Resource Demands

The power required in Plan 1, for the achievement of level one effluent standards, includes power consumed in primary treatment, in aeration, and by the use of microstrainers. The estimated consumption in the treatment of 794 mgd is 2040 megawatts per day. At the current cost of $0.0121 per KWH, the daily cost will be $24,684.00. The environmental and economic costs of this energy are discussed in an attachment. The chemical demand totals 474,000 pounds per day including chlorine, alum, lime and polymer at an estimated current cost of $12,000 per day.

d. Reliability

The reliability of any plan relates to methods of treatment and disposal of the residuals. As a level one, water-based plan, a conventional activated sludge process is used, followed by bacterial nitrification to remove ammonia, mixed media filtration, phosphorus removal and chlorination. The efficiency and reliability of the activated sludge process are known from considerable experience. It is necessary to indicate, however, that the effectiveness of some advanced treatment processes depends on the assured effectiveness of the secondary treatment, and that a failure of this process due to hydraulic or BOD shock or slug loading of any of a range of industrial wastes can lead to temporary deterioration of the entire process. The question of the educational level and quality of personnel needed to run the alternate plans has been raised. The answer is that even the simpler processes have failed and continue to fail due to the inadequacy of operation, and that the upgrading of processes should not inordinately increase the level of training required.

Chlorination may be expected to practically eliminate pathogenic bacteria in the effluent, provided a sufficient holding time is used or a chlorine residual is maintained. However, the treatment process will not remove the viral hazard. The lack of demineralization will permit the flow through of some toxic metals, and refractory organics will also be present. A system failure would result in the current practice of spilling untreated wastes into the streams and Lake Erie.

The disposal of sludges by incineration poses additional problems in the air pollution caused and in the landfill disposal of ash which may leach to the surrounding soil or to groundwater, residual minerals

and even, in some cases, undestroyed bacteria. Stormwater treatment is discussed separately.

e. Land Use Changes

Each of the plans differ somewhat in acreage requirements for collection, storage, transmission and treatment of stormwater and domestic wastes. These requirements impact the actual land to be used as well as adjacent land use activity. The consideration of land use controls in the region for effective limitation of stormwater runoff has been discussed previously in this report and can generally be related to all plans. In evaluating the individual plans comparatively, changes in land use are considered in terms of the quantity and use of the required land, as well as the scope of land areas affected.

Plan 1 is confined to the Three Rivers Basin. Its major land requirements are for 136 sedimentation-storage ponds and right-of-way for the Southwest interceptor. Over 800 tons per day of sludges for incineration will require additional acreage for landfill. Although landfill sites inhibit multi-use potential and present aesthetic problems of odor and negative visual images, the storage sedimentation reservoirs offer some potential for compatible recreation activity. The most highly urbanized areas in the basin will collect stormwater in the form of underground chambers or concrete-lined tanks, while the majority of storage areas are likely to be ponds with natural earth bottoms. Single purpose use of this land for stormwater collection neglects consideration of the storage ponds for recreational purposes which may appear more beneficial and acceptable to the public. Slight alteration in the reservoir design

would provide fishing and boating opportunities during most of the warmer months, and, due to their shallowness during normal times, the ponds could be used for skating during winter. Management requirements would necessitate enclosing the reservoir for shutdown during a major storm and prohibiting public use until the water returns to a safe level and acceptable degree of clarity. For a large portion of the year, however, recreational activity could be enjoyed.

Some general benefits for land development will derive from the plan's Level One quality treatment; improved water quality would enhance the potential of land adjacent to the water body.

f. Political/Public Perceptions

As was indicated in the general considerations, institutional factors are integral to evaluation of the plan's implementation potential. However, since political and public perceptions cannot be neatly arranged nor predicted at the drawing board this evaluation area is critically dependent on the responses of both public officials (local and state), and the general citizenry (local communities and the region as a whole). The plan's acceptability must be assessed in terms of relative harmony with the goals and objectives of the region's various publics, and with the flexibility of institutions.

Political and public reactions are difficult to anticipate or to compare among the individual plans. However, the factors certainly include the degree of regionalization, both physically and in terms of administrative scope, the relative amount of land required and its associated individual and community disruption, versus multiple use opportunities and conservational improvements. The waste or

recycling of resources will be a major factor, given a continuance of the present public environmental concern. In very general terms there will probably be no insuperable public or legislative obstacles to regionalization, given the federal and state insistence on basin-wide planning. Prior planning in the Three Rivers Watershed District has established some precedent. Regionalization has received a court mandated beginning in the Cleveland area. Water quality problems are widely exposed by both media and various environmental groups in the area and offer a firm basis for a program of public education.

Plan 1, based on the Northeast Ohio Water Development Plan but upgraded from stream quality standards to meet Level One effluent criteria, would have the impetus afforded by that planning effort in appealing for channels of official and general public acceptance, due to its congruence with current planning activity. However, the technical feasibility of Plan 1 as compared to alternatives must be considered in terms of the evaluation factors elsewhere presented in this report.

The additional costs involved in the upgrading to Level One criteria from the Northeast Ohio Water Development Plan's stream quality standards may be largely a function of the State's formal position on regulating water quality at a given level. Plan 1 suffers deficiencies in multiple use opportunities of the wastewater treatment process relative to other alternatives, and this may inhibit public acceptance. The design for 100% sludge incineration may be publicly perceived as a waste of resources which could provide reuse benefits related to regional goals.

g. Flexibility

The advanced biological system used in all Level One, water based plans is essentially a conventional activated sludge process with add-on treatment units for removal of specific pollutants. Changes in quality of influent or effluent required can be met by process additions or by conversion to land filtration. Adjustment to increased hydraulic flow is only marginally possible, while reduced flow would merely decrease the utility rate of the plant. The plan for the Southwest interceptor is a major commitment which would inhibit subsequent changes in treatment in the Rocky River Basin.

h. Stormwater Management

Urban runoff, collected in either separate or combined sewer systems, adds major pollution loads to the waters of the basin. Some 163 sub-drainage basins are identified within the Three Rivers Basin, with the runoff being collected in systems ranging from 122 to 136 separate areas. Stormwater is collected and stored to control the flow to treatment facilities and to take advantage of the sedimentation capabilities of the storage to reduce BOD and suspended solids. Each plan will control all combined overflows. Each plan will provide storage and treatment capacity for at least the one-year storm. Each plan envisions certain land-use regulations to limit runoff and measures to control non-point sources of pollution.

With the expected increase in urbanization, stormwater runoff from combined and separate sewered areas in 2020 would amount to 63% of the total runoff. Level One treatment would be expected to remove 68% of BOD and 63% of suspended solids at that time, plus increments of nitrogen and phosphorus. Level Two stormwater treatment would be

expected to remove 91% of BOD and 71% of suspended solids, again based on 2020 evaluation of the total (including rural runoff).

Given a level one treatment applied to both municipal sewage and stormwater runoff, urban runoff will contribute the following percentage of residuals to receiving waters: Suspended Solids--20%; BOD--36%; Total Nitrogen--4%; and Phosphorus--25%. If level two treatment were applied to municipal sewage while urban runoff received only Level One treatment, stormwater residuals would then amount to the same quantity but as a percentage of total discharge would be: Suspended Solids--46%; BOD--69%; Total Nitrogen--40%; Phosphorus--55%. While the relative increase is sizeable, the impact on the aquatic ecosystem will have to be assessed, and this probably cannot be done until the effect of other reductions can be examined. At any rate, the vast increase in cost between Level One and Level Two stormwater treatment will require the most careful examination.

The removal of suspended solids and BOD from stormwater by microstraining represents continuous, relatively trouble-free operation, easy to control and with a low maintenance cost. Removal capability varies from about 75-90% down to a minimum of 5 ppm. A major advantage is the small space occupied in relation to fixed filtration beds. However, the installation is subject to hydraulic overload and must have holding basins to control the rate of flow.

Plan 1 will treat stormwater in 132 separate basins, providing screening, storage and sedimentation, microstraining and final disinfection by ozonation

i. Hydrologic Effects

Plan 1 is a water-based plan, returning treated municipal effluent to streams and Lake Erie and treating stormwater close to the sub-basin of origin before release to streams. The major regionalization indicated by this plan is not supposed to have significant effects on the flow of the three rivers. Most affected will be the Rocky River which obtains much of its water at this time from streams and reservoirs, although Cleveland water is moving into the Brunswick area. The East Branch will lose about 4.4 cfs, while the North and West Branches will lose more than 23 cfs at several locations which will be returned to the river at Liverpool. Data on the current mean flows of these minor tributaries are not available for comparison, although the loss in the East Branch exceeds the mean flow at Berea at times. The effect of the diversion of 61.7 cfs at North Olmstead is described as not significant even though there is general agreement that flow augmentation would greatly improve the esthetic quality of the river.

j. Residuals

Residuals from Plan 1's water treatment to Level One criteria includes over 800 tons per day of secondary sludges for incineration and 124,000 tons of stormwater sedimentation per year. Some opportunity exists for recycling the sedimentation for use as topsoil, fertilizer and landfill by public works or private parties. The incineration of sludges will produce oxides of nitrogen and sulfur, particulates and various volatiles; it involves destruction of a resource and loss of opportunity for recycling.

k. Disposal Methods

The incineration of sludge generates demands on outside resources for power, fuel, transportation, and landfill areas. Air pollution control will be required. There will be potential leaching from the landfill disposal of the incinerated residuals. The residue is strongly basic and will produce localized sulfates and chlorides.

Industrial reuse potential for the effluent as process and cooling water will exist for factories in the lower Cuyahoga Valley in close proximity to the Cleveland Southerly Treatment Plant.

Limited streamflow augmentation will be provided in some upper reaches of the Chagrin and Cuyahoga Rivers, and thus may favorably affect stream use for recreational, environmental and water supply purposes.

2. Plan 2, Level One, Land Treatment

a. General Features

Plan 2 is an all land treatment system, providing secondary treatment to domestic, compatible industrial and combined sewage before application to the land within the basin and to the west. Separate storm runoff will be collected and treated locally by sedimentation, microstraining and chlorination before discharge to land or water. Land filtration is expected to provide tertiary treatment to secondary effluent with underdrainage and discharge to adjacent streams. Longterm winter storage will be required.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	8	S	26	3,983
Chagrin River	7	S	30	4,200
Cuyahoga River	15	S	68	13,039
Lake Erie	5	S	12	---
	35		136	21,222

(1) Sludge Disposal

Concentration, stabilization and transmission to stripmines 93.6%

Concentration, stabilization, disinfection, land treatment 6.4%

(2) Facilities Required

A land treatment area of 18,783 acres will be required in the Three Rivers Basin; winter storage will take an additional 2439 acres, 20 feet deep. Storm water treatment will require upstream ponding, overflow holding basins and storage-sedimentation basins sized for storage of the 1-year storm. Seven hundred to 1,000 acres of storm water detention will be needed where land application is scheduled,

sizing must be increased to accommodate winter storage. An effluent tunnel capable of transmitting 679 mgd to agricultural land in North Central Ohio is projected, with about 152,000 acres of treatment and winter storage area required.

(3) Special Features

The use of storage reservoirs for the flow returned from land treatment is planned, generally in the areas proposed by the Northwest Ohio Water Development Plan. The reservoirs will be used to control the flow in the rivers affected. The application rate in this plan will be gauged to the rate of crop uptake of nitrogen. Land treatment return flows in the Upper Cuyahoga River will be used to supplement Lake Rockwell and ground water supply in the basin. The concept of the rehabilitation of strip mined lands in eastern Ohio counties is introduced, using sludge transmitted from secondary plants via an existing pipe line to Harrison County.

b. Ecological Considerations

(1) Community Energetics

Plan 2 requires the least input of irreplaceable resources in the form of energy and processing chemicals. Energy requirements for treatment alone are moderate. It contributes most toward a stable P/R ration (functional index of the stability of the ecosystem), promotes the development of complex food chains and will minimize the return of humic material to the ecosystem of origin. It will require the highest amount of labor and energy to maintain stability in receiving ecosystems (agricultural lands, strip mines).

(2) Community Structure

As a Level One plan it provides a lesser encouragement to the diversity of aquatic life than Level Two plans. For the same reason, there is a lesser contribution to the development of stratification and organized communities, or to species with a narrow tolerance to environmental factors. In the land treatment, biotic storage of plant nutrients is maximized.

(3) Nutrient Cycling

Plan 2 maximizes recycling of nitrogen and phosphorus, reuse of organic sludges as soil conditioners, and biological control of nutrient cycles. The plan generates the least sludges with poor reuse potential. The plan has the potential of disturbing "natural" hydrologic regimes and threatening the quality of ground water supplies through the leaching of nutrients.

(4) Life History

Niche specialization, a larger size of organism and longer, complex life cycles, all characteristic of mature aquatic ecosystems, are encouraged by this plan. Although land treatment generally will achieve a higher effluent quality, Level One stormwater treatment with discharge to water will reduce this characteristic to a moderate level.

(5) Selection Pressure

This plan will provide less feedback control of aquatic populations Since disturbed ecosystems (in land use) may produce rapidly growing nuisance organisms, this system is potentially vulnerable. Control of pathogens in effluent is potentially high.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist the disruption of outside influences. Plan 2 provides least encouragement to organism interrelationships, interferes more with natural ecosystem succession development, but promotes the rehabilitation of damaged ecosystems in strip mined territory. The plan generates lesser quantities of potentially harmful aerosols, but provides lesser protection for system failure in some aspects. The plan will require major disturbances in terrestrial ecosystems (land use) and considerable interconversion of aquatic and terrestrial systems (storage ponds). It is most protective of plant, animal and human life from potential accumulation of toxic metals and other chemicals.

c. Resource Demands

Power requirements in Plan 2 for Level One treatment standards includes power consumed in secondary treatment. The estimated consumption in treatment alone is 1730 megawatts per day. Transmission costs are not included. At the current cost of $0.0121 per KWH, the daily cost will be $20,933.00. The enviromental and economic costs of future energy supply are discussed later in this report. The chemical demand totals 118,000 pounds per day in lime, alum, chlorine and polymers with an estimated current value of $3,855 per day.

d. Reliability

Plan 2, is an all land plan requiring secondary treatment of sanitary wastes by activated sludge treatment within the Three Rivers Basin and transmission of most of the secondary effluent by tunnel to

land in North Central Ohio. The effluent would be applied by one of several irrigation techniques, filtered by the soild and returned through under-drains to collection points or discharged to streams. The reliability of the land treatment is widely accepted but the operator has essentially no control over the treatment process once the wastes are applied. The efficiency of the system will depend on the strictest management of application relative to climatic and soil conditions, environmental monitoring, and crop supervision. Land treatment is relatively independent of changes in quantity or quality of effluent and may be expected to compensate for failures in secondary treatment. A breakdown in major transmission lines, particularly the single effluent tunnel, would result in the discharge of secondary effluent to the waterways.

The plan anticipates the retention of metals in the soil with a resultant buildup. While this fixation is more advantageous than the uncontrolled discharge to water, the question of selective uptake of metals by plants being used for human or animal food needs further investigation. At the same time, cropping is essential to removal of nitrogen from the effluent deposition. There is a hazard in the irrigation process of spreading bacterial populations but the filtration process and the hostile and competitive population in the soil reportedly removes all bacteria. Virus removal is less certain. The information on ground water quality in areas suggested for treatment is minimal and needs to be upgraded to provide a baseline before land application is initiated.

e. Land Use Changes

Plan 2 proposes the application of secondary effluent to land, the creation of reservoirs for winter storage, and additional acreage requirements for stormwater detention and treatment. Major transmission lines will be required to pipe effluent from the Akron-Cleveland areas to agricultural lands in North Central Ohio. Pipelines will be needed to carry sludge from the basin to strip mine areas in eastern Ohio, but an unused coal slurry pipeline from Lake Erie to Harrison County will either serve or provide right-of-way. Land treatment is planned for more than 170,000 acres of agricultural land, with over 20,000 acres in the basin. Additional land will receive sludge for reclamation, but since this is largely unusable at present, no constraint is anticipated.

If the land for treatment areas is purchased by public agencies, considerable acreage would be lost to the tax duplicate in several western counties. Significant dislocation of farm families could result, although some might remain in land management. Similar displacement will result in more densely populated basin areas where even a minimal disruption may be exaggerated by community reaction. An alternative, warranting careful consideration, would be the retention of private farm ownership with farms accepting secondary effluent on a long term contractual basis. In addition to constraining community disruption and offering potential production increases to farmers, such a program would avoid the cost of farm management. In areas adjacent to the treatment sites, property values may drop as a result of deflated aesthetic perceptions associated with sewage

treatment. However, adequate public communication programs, and proper management could alleviate the disaffection.

Land management, particularly in the basin, could provide significant open space and wildlife habitats. Land treatment sites could be advantageously located in areas where unique biological habitats merit preservation and in paths of urban development where conservation of greenbelts is appropriate.

Of major importance in this plan is the transmission of secondary sludges to strip mine areas for reclamation purposes. The application of high pH, high organic and high nutrient value sludges to acid subsoil will serve to recondition and fertilize the soil. Considering the availability of thousands of acres of vandalized land, this constitutes a conservation measure of high priority.

The application of waste waters to thousands of acres of land will create a wetter ecosystem which can disturb the natural state of the area, modify the micro-climate, may alter the land form, vegetation and wildlife, increase evaporation loss, and may create environments for new life forms, particularly plants and insects. The change in insect population and the provision of cover for wildlife may also affect the incidence of plant, animal and human disease on a host-vector basis. The requirement for crop removal of nitrates may mandate a managed agriculture in the area and could lead to local oversupply and marketing problems.

Stormwater sedimentation/storage reservoirs offer potentials similar to those outlined in Plan 1. The large volume capacities of winter storage reservoirs associated with land treatment may offer potential for power plant cooling if properly sited, thereby constraining the thermal pollution of Lake Erie for cooling purposes.

f. Political/Public Perceptions

Plan 2 introduces land treatment of secondary effluent in the wastewater management process and concerns land in-basin, agricultural lands in North Central Ohio and stripmined land south of the watershed. Essentially, the land treatment process involving extra-basin areas will present increased pressure against political and administrative accommodation. A significant impact on the public perception can be expected, due to the high visibility and large areas required for land treatment.

The requirement for extra-basin transmission of secondary effluent may well create major problems of public acceptance in the western basin, especially if not preceded by adequate demonstration and in-basin acceptance of land treatment. The intergovernmental structure required for land acquisition and management of land treatment processes will largely depend on public demand for conservation of resources and application of environmental controls, as well as administrative flexibility.

The land treatment process will be more likely to gain public approval if the specific uses of the land are congruent with adjacent land use, can provide multiple-use activities, and do not degrade the present appearance of the landscape. Thus, land sites would be more acceptable if supportive of recreational development or agricultural activity. Sludge application on strip mine land in Harrison County or adjacent areas should evoke strong public favor, due to the overwhelming benefit of reclaiming vandalized land; this use contrasts to the alternate sludge disposal process of incineration and landfill, which wastes resources.

g. Flexibility

Plan 2, as most land plans, begins with conventional activated sludge treatment with the secondary effluent transmitted to selected land areas for treatment by passage through a soil filter. The land treatment process is essentially indifferent to changes in effluent quality and can be adjusted to quantity changes by the use of more or less land. The development of complete and valid secondary treatment in the basin will be compatible with either land or fixed tertiary treatment. The use of land in the upper basins for treatment can readily expand within limits or revert. However, a decision for construction of transmission facilities to apply nutrients to agricultural lands in North Central Ohio would essentially commit the area to this form of treatment for the useful life of the system.

h. Stormwater Management

The discussion of stormwater in Plan 1, generally applies to this plan as well. Stormwater will be treated in 132 basins by screening, storage and sedimentation, microstraining and final disinfection by ozonation. The effluent would be released locally, either to land in sections of the upper basin or to water.

i. Hydrologic Effects

The hydrologic significance of an all land plan lies in the transfer of nearly 700 mgd of wastewater generated in the Three Rivers basin to North Central Ohio basins. In the upper basins, greater flow is contributed by land treatment than is generated in that area but the effluent from sanitary treatment in the middle and

lower basins is not returned to the river. This amounts to 58 mgd in the Rocky River, 24 mgd in the Chagrin River and about 323 mgd in the middle and lower Cuyahoga. The amount normally discharged directly to Lake Erie is not considered. While these amounts do not approach the mean flow they are considerably above the critical low flow for each river.

Two hydrologic effects are noted in the river basins to the west: the introduction of excess water, and the drainage of large areas of land. The effect of drainage will be to lower the water table by accelerating the draw-down of the normal supply. The impact of the return flow from irrigation would be to increase discharge to local streams during the irrigation season. The maximum potential return flow is never greater than 15% of the mean annual flood. The use of up-ground reservoirs as contemplated in the Northwest Ohio Water Development Plan and the release of water during low-flow periods in summer are indicated. Erosion and deposition mechanisms in the streams affected will require further study.

j. Residuals

Residuals from the secondary treatment plants in Plan 2 include 511 dry tons per day of secondary sludges and about 124,000 tons of stormwater sedimentation per year. Ninety-four percent of the sludge is scheduled for strip mine application and the rest for land application. Sedimentation residues are to be used as top soil or land fill. All of the effluent will be used for land irrigation.

k. Disposal Methods

The costs generated by disposal include the major transmission costs of the effluent plus the management required for strip mine

rehabilitation and agricultural operations. The effluent disposal constitutes a major recycling of valuable nutrients through crop production. The reservoirs for low flow management will anticipate a potential use for power plant cooling. Power plant cooling potential also exists in use of the effluent tunnel for once through cooling by shoreline power plants. Opportunity exists for land treatment of the wastes of many cities in Northern Ohio which lie near the effluent tunnels in this plan.

3. Plan 3, Level Two, Water Disposal

a. General Features

Domestic, compatible industrial and all urban storm runoff will be collected and treated in advanced wastewater treatment plants. Separate stormwater will be stored and treated in offpeak capacity of the AWT plants. Smaller plants, less regionalized than Plan 1, are used in upper basins, thus augmenting river flows.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	7	AWT	--	For Stormwater
Chargin River	7	AWT	--	detention only
Cuyahoga River	10	AWT	--	
Lake Erie	5	AWT	--	
Total	29		0	2,100

(1) Sludge Disposal

Concentration stablization and transmission to strip mines 37%

Holding, concentration, incinceration, ash to landfill 61%

Concentration, stabilization, disinfection, land treatment 2%

(2) Facilities Required

In the treatment of urban runoff, to Level Two standards, stormwater is collected in 136 detention basins, providing storage for an average 30 day rainfall (9,915 mg). The runoff is held for mixing and flow levelling and is discharged into the sewer system and carried to the plant for treatment during the hours of low sanitary flow.

(3) Special Features

Stormwater flows to the sanitary treatment system are so large that they dictate plant enlargement over the required capacity to treat the average municipal flow. Since many stormwater basins discharge into each treatment plant, extensive automatic flow controls will be required to prevent loadings beyond the peak design sanitary flow.

b. Ecological Considerations

(1) Community Energetics

Plan 3 requires the input of relatively large amounts of outside resources and power for its operations, does not contribute to a stable P/R ratio (functional index of the stability of an ecosystem), does not promote complex food chains and provides only a moderate return (39%) of humic material to the ecosystems. It requires a moderate expenditure of energy to maintain stability in receiving ecosystems.

(2) Community Structure

As a Level Two plan, this provides most encouragement to diversity of aquatic life, to highly organized communities and to species with a narrow range of tolerance to the environment, all normally evident in a stable ecosystem. The plan minimizes biotic storage of plant nutrients.

(3) Nutrient Cycling

The plan makes some provision for recycling of nitrogen and phosphorus, but destroys much of the organic sludges, minimizes

biological control of nutrient cycling and generates large amounts of chemical sludges. It may provide a moderate threat to ground water quality by leaching of incinerator ash from landfill but will have little effect on "natural" hydrologic regimes.

(4) Life History

As a level two plan, this will provide most encouragement to niche specialization, a larger size organism and longer, more complex life cycles, all of which are characteristic of mature ecosystems.

(5) Selection Pressure

This plan will be more compatible with feedback control of growth forms, and the control of nuisance organisms. It will have a lesser effect on the control of pathogens in water.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist disruption by outside influences. Plan 3 provides least encouragement to organism interrelationships, interferes more with natural ecosystem succession and promotes a limited rehabilitation of a damaged ecosystem (strip mines). The plan provides maximum protection for the ecosystem in the event of mechanical failure, generates a moderate amount of potentially harmful aerosols by regeneration and incineration, but provides the least disturbance to the land. At level two it provides moderate protection from the cumulative effects of metals and other toxins.

c. Resource Demands

Plan 3 requires 2460 megawatts per day of power for the provision of tertiary treatment, including carbon absorption, denitrification, mixing and primary treatment. At a current price of $ 0.0121 per kwh the daily cost would be $26,766.00. The environmental and economic aspects of power generation and resource uses are discussed later in this report. The chemical demand totals 833,000 pounds including chlorine, alum, lime, methanol and polymers, with an estimated current cost of $98,025 per day. Additional chemicals are utilized in stormwater treatment.

d. Reliability

The Level Two treatment in this plan is achieved by a conventional activated sludge treatment followed by biological nitrification, anaerobic denitrification using a methanol supplement, mixed media filtration, phosphorus removal, carbon adsorption for refactory organics and final chlorination. The efficiency of the processes in train are dependent in some measure on the quality of the activated sludge effluent, and the conditions that can shock or poison this process are well known. Mixed media filters and carbon adsorption columns are both affected by variations in suspended solids. The refractory organics in secondary effluent are in the form of tiny colloids. While too small to be filtered, they are resistant to adsorption and may pass through the process. The chemical character of the refractory organics at a final low concentration is not well known, and neither is their public health significance. The adsorption and final chlorination will remove

pathogenic bacteria provided sufficient holding time is used or a chlorine residual is achieved. The treatment process will not remove the viral hazard. Carbon adsorption apparently becomes exhausted relative to viral concentrations before organics and will release viruses under these circumstances.

The reliability of a system treating stormwater in periods of low municipal flows is unknown since it has not been tried on a large scale basis previously. Whether the dilution will degrade the biological process or disrupt its efficiency cannot be predicted on the basis of current information, Lack of demineralization will permit some flow through of toxic metals. A plant failure would permit the overflow of untreated or partially treated wastes to water. The disposal of sludges by incineration and landfill poses problems in air pollution and potential ground water pollution. Similar pollutional problems exist with land disposal of sludge although the use in stripmine rehabilitation enters into an ecosystem so degraded as to make any addition an improvement.

e. Land Use Changes

Plan 3, a water disposal system with effluent treated to Level Two criteria , projects land use changes somewhat similar to Plan 1. Plan 3 is confined to the basin with the exception of approximately 1/3 of the sludge transmitted for disposal on strip mined land. Some 60% of sludge is incinerated with the ash going to landfill, requiring in-basin acreage unsuitable for any other use and negatively affecting the esthetics of adjacent land. A minimal sludge volume will be applied to agricultural land in the basin, effecting minor changes in current land use practice.

The principal land requirements of Plan 3 are for 9,915 million gallons of stormwater detention storage for which multi-use potentials noted in Plan 1 are applicable. The detention storage basins will restrict stormwater runoff and thereby reduce flooding in the basin.

Plan 3 provides for less regionalization in the Rocky River Basin, but has fewer, larger plants in the Chagrin and Cuyahoga Basins. All plant capacities are increased for the advanced treatment of stormwater, as required by Level Two effluent criteria.

f. Public/Political Perceptions

Plan 3 indicates increased regionalization in plant configurations for the Chagrin and Cuyahoga Basins and thus emphasizes problems of intergovernmental coordination for financing and administration essential for implementation of a regionalized system. Public reaction to the increased costs and water quality objectives of Level Two, will depend on the intensity of enviromental concern, the incremental costs above Level One at the time of phasing, and the demonstration of enviromental need subsequent to the implementation of Level One treatment.

g. Flexibility

In Plan 3, the advanced biological system used in all plants is essentially a conventional activated sludge plant with add-on treatment units for removal of specific pollutants. Changes in the quality of influent or effluent or in the waste treatment standard can be met by process additions. The system is relatively inflexible for resizing to meet an increase or reduction in hydraulic

flow. If it is eventually decided that urban runoff does not require the same degree of treatment as sanitary waste, there will be no way of separating the combined flows. The expense of the stormwater collection and storage may be so great as to delay its phasing until some time after the sanitary system, resulting in plants with major overcapacity. Finally, the costs involved in a total Level Two treatment are such that any conversion to other systems would be most unlikely.

h. Stormwater Management

Plan 3 is a level Two plan and carries stormwater treatment to this level as well. Stormwater is collected in 136 basins, providing a storage total of 16% of annual runoff, equivalent to a 100 year storm. Runoff will be transmitted to the AWT plants for treatment in the off peak hours.

There are several difficulties involved in the combined treatment of municipal and stormwater wastes. There is no experience with flows of this magnitude and the efficiency of the process is uncertain. There is no way to separate storm water from sanitary sewage if it requires less treatment. The phasing of stormwater treatment may occur years later than Level Two sanitary treatment and make a combined plan design uneconomical.

i. Hydrologic Effects

The diversion of stormwater downstream to regional plants will reduce the flow in several reaches of streams and may completely dry up some small tributaries.

j. Residuals

The residuals from the tertiary treatment plants in Plan 3 will total 931 dry tons per day, or about 340,000 tons per year. Stormwater detention and treatment will result in more than 155,000 tons per year, an average of 425 tons per day. In some respects, the chemical burden added to the organic sludges makes it less suitable for recycling through strip mine or agricultural use. The effluent will be discharged to waterways.

k. Disposal Methods

Since 61% of the residual sludge is incinerated, the costs of air pollution and the loss of resources are apparent. The application of the remainder of the sludge to stripmined areas and upper basin agricultural land will recycle nutrient resources and rehabilitate the land. Incineration generates demands on outside resources for power, fuel, transportation and landfill areas. Strip mine application requires continuing management. Pollutional hazards exist in both landfill and sludge application. However, the subsoil mineral content in strip mine areas renders the sludge application relatively innocuous. Other reuse opportunities appear to exist for industrial processing and cooling in the lower Cuyahoga industrial valley.

4. Plan 4, Level Two, Land Treatment

a. General Characteristics

All domestic and compatible industrial sewage will be treated in secondary plants and conveyed to land treatment sites in the basin and to the west. Combined sewage is also given secondary treatment but when it exceeds capacity in the Cleveland-Akron area, the overflow will be treated in new primary plants before conveyance. Separate storm flows in the metropolitan area may be stored, treated in secondary plants before transmission or given sedimentation, microstraining and chlorination before release to land treatment. Management will be directed toward flow augmentation. Land treatment areas in basin will receive sludge along with effluent, regulated on the basis of soil and crop needs.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	8	S	12	5,090
Chagrin River	7	S	12	5,325
Cuyahoga River	15	S	13	17,364
Lake Erie	4	S	1	423
Total	34		38	28,202

(1) Sludge Disposal

Concentration, stabilization and transmission to stripmines 95.5%

Concentration, stabilization, disinfection, land treatment 4.5%

(2) Facilities Required

Land treatment acreage of about 25,500 acres will be required in the basin, and winter storage requirements will add about 2,700 acres at an assumed 20' depth. Three primary plants for treatment of combined overflows will be added at Cleveland and Akron. It is

suggested that the overflows receiving only primary treatment will get secondary treatment in aerated lagoons at the western land treatment sites. Since segregation in the effluent tunnel would be impossible, such treatment might have to be applied to all discharges to the effluent tunnel. Detention storage is proposed for approximately 8863 million gallons in metropolitan storm basins, with the largest holding 891 mg.

(3) Special Features

This plan introduces the concept of aerated lagoons to provide supplemental treatment to effluent transported from the Three Rivers Basin. Flow through cooling using the effluent tunnel is suggested for shoreline power plants which now discharge directly to Lake Erie. In addition, the potential siting of power plants to use the year round cooling capacity of secondary effluent storage ponds in the western land treatment areas is introduced.

b. Ecological Considerations

(1) Community Energetics

Plan 4 requires least input of chemical resources and energy for treatment, contributes to a stable P/R ratio (functional index of the stability of the ecosystem), promotes complex food chains and returns humic material to the ecosystem. It requires the most human effort and energy input to manage its residuals (agricultural and strip mine application).

(2) Community Structure

The plan provides most encouragement to a diversity of aquatic life, to highly organized communities, and to species with a narrow tolerance to environmental factors, all evident in a stable ecosystem. The plan maximizes biotic storage of plant nutrients.

(3) Nutrient Cycling

Plan 4 maximizes recycling of phosphorus and nitrogen, the reuse of organic sludges, the biologic control of nutrient cycling, and generates the least inorganic sludges. As a land plan it has the highest potential for disturbing stream flow and threatening the quality of ground water supply.

(4) Life History

Niche specialization, a larger size organism and longer, complex life cycles, all characteristic of mature aquatic ecosystems, are highly encouraged by this plan.

(5) Selection Pressure

This plan will provide less feedback control of populations and potentiates the development of fast growing nuisance organisms typical of disturbed ecosystems. Control of pathogens appears most effective.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist the disruption of outside influences. Plan 4 will provide most encouragement to organism interrelationships, interferes least with successional development, provides moderate rehabilitation potential and generates least quantities of hazardous aerosols. In contrast, it requires the most disturbance and interconversion of terrestrial ecosystems and provides less protection for the ecosystem in case of mechanical failure. As a land plan it provides greater protection of plant, animal and human life from cumulative toxic effects of metals and other chemicals.

c. Resource Demands

Plan 4 will require 1730 megawatts of power per day for secondary treatment, involving a cost of $20,933 at the current rate of $0.0121 per KWH. Reference is made to the paper discussed earlier on the environmental and economic costs of power and chemicals. Plan 4 requires the least amount of chemical input but uses lime, chlorine, aluminum sulfate and small amounts of polymers, currently costing about $3,855 per day.

d. Reliability

The process in Plan 4, as in Plan 2, is that of providing secondary treatment in the basin prior to transmission of the effluent to land areas, both in and out of basin, for land treatment. The reliability of treatment under application rates of 90 to 150 inches per year, particularly on soils in the Rocky River Basin, remains to be demonstrated. The treatment of stormwater in the low use periods of the sanitary treatment plants, subjects these plants to a hydraulic shock, with little available information on the efficiency of such a combined operation. The questions of reliability, noted in Plan 2, also apply to Plan 4.

e. Land Use Changes

Plan 4 has land requirements similar to those of Plan 2, and the consideration of change is equally applicable. Land treatment acreage of more than 28,000 acres will be required within the basin, including winter storage. Possibly 1800 to 2000 acres additional will be needed for stormwater detention basins, unless they can be combined in some way with winter storage. Should the application rates suggested in Plan 4, prove to be too high for the soils

encountered, the possibility exists that additional acreage will be required (up to 20,000 acres) depending on rates finally established. Treatment and storage areas in North Central Ohio will require approximately 170,000 acres of agricultural land.

Since the combined sewer overflows from Cleveland and Akron, will receive only primary treatment before transmission to the west, aerated lagoons are planned at the land management sites for supplemental treatment prior to irrigation. The use of aerated lagoons will compound the problem of western land treatment, since additional land will be converted to water and other problems are introduced, including potential aesthetic nuisances.

Plan 4 proposes the disposal of sludge by application in strip mine areas as well as application to agricultural land within the basin. The use of sludges for reclamation of land now relatively worthless, must be regarded as highly favorable. The minimal amount of sludges applied to agricultural land (4.5%) may require some management, may create problems initially of adverse public reaction, and will alter soil composition. However, the impact of land treatment, both in the basin and in North Central Ohio, will be highly dependent on the effectiveness of management schemes, as discussed in Plan 2.

f. Political/Public Perceptions

Plan 4's requirement for extra-basin transmission of secondary effluent and increased basin land use for treatment could magnify problems of public acceptance, particularly if adequate demonstration is not provided to counteract negative political and aesthetic perceptions. The use of primary treatment for storm overflows and

the transmission for treatment to aerated lagoons to the west may constitute another obstacle.

g. Flexibility

The flexibility considerations in Plan 4 are the same as those in Plan 2. Secondary treatment plants can be readily expanded to provide tertiary treatment provided sufficient land exists. However, the commitment to an effluent tunnel with its major capital investment, would necessitate the continuation of land treatment for the useful project life.

h. Stormwater Management

A discussion of the treatment level applied to stormwater runoff appears under Plan 1. In this plan, with a Level Two requirement, stormwater is treated, both in secondary plants in combination with sanitary sewage, and in 38 separate stormwater treatment plants before diversion to land treatment.

i. Hydrologic Effects

The hydrologic effect is essentially the same as in Plan 2. The major impact will be presented by the transfer of over 700 mgd of wastewater to river basins in North Central Ohio. The upper sections of the Three Rivers Basin will not suffer, since the return flow from land treatment is greater than the withdrawal from surface and ground water sources. There is less combination of stormwater treatment in this plan than in Plan 3 with treatment in the basin at origin where possible, and this serves to augment the diminished flows. However, the effect is still significant and will generally eliminate the potential for water reuse within the basin. The

hydrologic effects on the basins to the west are noted in Plan 2.

j. Residuals

The residuals from the secondary treatment plants in Plan 4 are 511 dry tons per day of sludge, over 186,000 tons a year. Stormwater detention and treatment will produce more than 117,000 tons per year, an average of 320 tons per day. In addition, the secondary effluent will be available for land irrigation and the recycling of the nutrients not removed.

k. Disposal Methods

The costs generated by disposal methods include drying before use on agricultural land, and the transmission and management costs of this and the strip mine application. In addition to nutrient recycling, the storage ponds for the effluent have the potential of serving as a cooling system for a power plant sited in the immediate area. The possibility also exists for using the effluent tunnel as a once through cooling device for power plants now using Lake Erie waters along the shoreline.

5. Plan 5, Level One, Combination Land/Water Based

a. General Features

This plan divides the Three Rivers Basin into three further areas for treatment: upper, middle, and lower/shoreline sections. In the upper basin where densities are low and land is available, secondary treatment and land application are used. In the middle basin where density is greater, advanced waste treatment is used with discharge to streams. In shoreline areas, similar treatment results in discharge to Lake Erie. Domestic, industrial, and combined sewage would receive tertiary treatment. Separate storm water runoff will receive at least sedimentation, microstraining, and disinfection. Some stormwater will receive advanced treatment at plants converted from current sewage treatment.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	8	3S, 5T	25	597
Chagrin River	7	5S, 2T	25	2,833
Cuyahoga River	16	9S, 7T	57	2,534
Lake Erie	5	T	9	--
	36		116	5,964

(1) Sludge Disposal

Holding, concentration, incineration, ash to landfill (44.8%)

Concentration, stabilization, transmission to strip mines (50.4%)

Concentration, stabilization, disinfection, land treatment (4.8%)

(2) Facilities Required

Urban storm runoff is generally treated locally and discharged to water, but use is made of land treatment when convenient. Additional stormwater treatment capacity is provided at Kingsbury Run, Mill Creek, Easterly and Westerly plants to treat combined sewer overflows. Stormwater detention will require about 900 to 1,000 acres of land to store over 4500 million gallons. Eight existing plants are converted to stormwater treatment.

(3) Special Features

Plan 5 emphasizes water disposal with only 3.3% of the effluent going to land treatment even though half the plants are secondary. Some flow augmentation is practiced since over 6% of the effluent goes to land or water in the upper basins as opposed to less than 1% of water supply originating there. Middle basin tertiary plants also provide supplemental stream flow.

b. Ecological Considerations

(1) Community Energetics

Plan 5 requires the input of moderate amounts of chemical resources and power, contributes little to a stable P/R ratio (functional index of the stability of the ecosystem), does not promote complex food chains and returns part of its humic materials to the land (55% of sludge). It will take some expenditure of energy to manage the residuals.

(2) Community Structure

As a Level One plan it provides least encouragement to the diversity of aquatic life, to highly organized communities or to species with a narrow range of tolerance, all normally evident in a stable ecosystem. The plan provides for limited biotic storage of major plant nutrients.

(3) Nutrient Cycling

The plan provides for minor recycling of phosphorus and nitrogen, uses about half its sludges as soil conditioners, provides minimal biological control of nutrient cycles. It generates some inorganic sludges but provides little disturbance to stream flow and a minimal hazard to ground water.

(4) Life History

As a Level One plan, little contribution is made to niche specialization, a larger size of organism and more complex life cycles which are characteristic of more stable ecosystems.

(5) Selection Pressure

As a plan primarily oriented to water discharge of treated effluent, Plan 5 is highly compatible to ecosystem feedback control of populations. To the small extent this plan is land oriented, the plan will both potentiate the growth of nuisance organisms and control pathogenic organisms.

(6) Overall Homeostasis

To the extent of its land influence, Plan 5 promotes

organism interrelationships and successional development, provides only minor land disturbance or interchange and promotes land rehabilitation by using 50% of the sludge for strip mines. The incineration of 45% of its sludges promotes air pollution and its minor land factor does little to upgrade overall protection from the cumulative effects of toxic wastes.

c. Resource Demands

Plan 5 will require 2791 megawatts of power per day for secondary and tertiary treatment. At a current cost of $0.0121 per KWH the cost will amount to $33,771 per day. The resource requirements will amount to 445,540 pounds of chemicals, at a cost of $11,331 in current value. Future environmental and economic factors are discussed in an attachment to this report.

d. Reliability

The reliability of any plan relates to methods of treatment and disposal and in some cases transmission. Plan 5 combines Level One water based treatment with a small increment of land treatment in the upper basins. The effectiveness of a high rate of application (90") in some areas, is still to be demonstrated. In general, the characteristics described under this section for Plans 1 and 2 apply.

e. Land Use Changes

Plan 5 emphasizes water disposal in a combined land/water treatment system and land requirements are confined to the Three Rivers Basin with the exception of stripmined land in Harrison County for 50% of sludge disposal. Major land requirements are for

stormwater detention ponds and approximately 6,000 acres in-basin for land treatment. Landfill areas for incinerator ash will require additional isolated acreage. Considerations of flood control and multi-use potentials are applicable for stormwater detention ponds. The relatively small acreage requirements indicate minimal concern for dislocation and property change effects. The application of secondary effluent to limited areas in the basin will not result in major changes in the ecosystem, although environmental changes may create new habitats for insect and animal life. Some changes may be introduced in agricultural practice.

f. Public/Political Perceptions

The tentative first step into land treatment within the basin indicated in Plan 5 will probably meet with less public resistance than other plans with wider demands on the land. However, evaluation of the plan in comparison with alternatives must also consider the technical efficiency and system flexibility in terms of relative satisfaction of water quality objectives now and in the future.

The regionalization potential in terms of institutional response for Plan 5 is similar to that discussed in Plans 1 and 2. The conversion of eight existing plants to Storm Water Treatment Plants (SWTP) as designed in Plan 5 is a factor which may favorably impress the public. Although the effect of retiring existing plants related to local bonded indebtedness and community finances may be reduced by federal/state/local financing arrangements, the general public may still perceive discarding of useful plants negatively. Thus, the conversion of existing facilities in the plan will be viewed favorably.

g. <u>Flexibility</u>

The combination plans exhibit the highest flexibility, as an overall plan for adjusting to change in the philosophy and direction of wastewater management. As a Level One plan, the investment and physical structure is such that changes to larger land increments or to higher level advanced treatment is possible.

h. <u>Stormwater Management</u>

Stormwater treatment is discussed in Plan 1. This plan will provide sedimentation, microstraining and chlorination to storm water runoff, generally in the basin of origin. The effluent will be released locally, either to land or water.

i. <u>Hydrologic Effects</u>

No significant hydrologic changes are anticipated under this plan. Flow augmentation is practiced with over 6% of the effluent going to land or water in the upper basins. Detention storage will control flooding.

j. <u>Residuals</u>

The residuals from the secondary treatment plans include 868 dry tons of sludge per day, about 317,000 tons per year. Stormwater detention and treatment will produce about 131,000 tons per year for an average of 360 tons per day. The residual effluent from tertiary treatment will be relatively free from transported matter.

k. <u>Disposal Methods</u>

Since 45% of the sludge is incinerated (150,000 tons per year) the same costs and deficiencies apply to this procedure as in Plan

The same benefits accrue to the 50% of sludges conveyed for strip mine reclamation as discussed in Plan 2.

6. Plan 6, Level One, Combination Land/Water Based

a. General Features

This plan categorizes the three basins into upper, middle, and lower/shoreline sections. In the upper basin, domestic/industrial sewage is given secondary treatment and land irrigation. In middle basins, sanitary and combined sewage is treated in advanced waste treatment plans and released to the rivers. These include Akron, North Olmsted, Kent, Bedford Heights, Macedonia, and Cleveland Southerly. Shoreline plants provide secondary treatment and release to the effluent transmission tunnel to the west. Separate stormwater will receive at least sedimentation, microstraining, and disinfection. In several locations stormwater will be treated in AWT plants in off-peak hours.

Plant Configurations	No.	Type	SWTP	Acreage in Basin
Rocky River	8	7S,1T	25	3,983
Chagrin River	7	S	25	4,791
Cuyahoga River	17	12S,5T	58	7,248
Lake Erie	5	S	9	
Total	37		117	16,022

(1) Sludge Disposal

Holding, concentration, incineration, ash to landfill	50.6%
Concentration, stabilization, and transmission to strip mines	41.8%
Concentration, stabilization, disinfection, land treatment	7.6%

(2) Facilities Required

Additional primary capacity is supplied for treatment of combined overflows at Easterly (Doan Brook), Westerly, Kingsbury Run, and Mill Creek, before discharge to the effluent tunnel. About

64,000 acres will be required for land treatment to the west, using an annual application rate of 67 inches. In-basin, stormwater detention will require from 600 to a 1,000 acres of pond surface, depending on the depth. The 16,000 acres of land treatment area in the basin, includes winter storage, based on a 22 week period.

(3) Special Features

Eight current plants are converted to SWTP in this plan. Use is made of several rapid infiltration basins in the Chagrin watershed. The plant configurations in Plans 5 and 6 are generally similar. The major difference is in the conversion of the lower basin shoreline plants from tertiary to secondary treatment and the construction of a tunnel to convey secondary effluent to agricultural lands in North Central Ohio.

b. Ecological Considerations

(1) Community Energetics

The conversion of a number of plants from tertiary treatment as in Plan 5 to secondary treatment, reduces power consumption about 10% and chemical input about 35%. With land treatment constituting a major part, the plan encourages a stable P/R ratio (functional index of the stability of an ecosystem), promotes complex food chains, and returns moderate amounts of humic materials to the ecosystem. It will require major expenditures of energy to maintain stability in the receiving ecosystems (agriculture and stripmines).

(2) Community Structure

As a Level one plan, there is lesser encouragement to diversity of aquatic life, to highly organized and stratified communities or to species with a narrow range of tolerance. Biotic storage of plant nutrients is increased.

(3) Nutrient Cycling

The plan recycles major amounts of phosphorus and nitrogen, uses only 50% of sludges for soil conditioning and has a medium effect on biological control of nutrient cycles, generation of inorganic sludges, and hydrologic regimes. It may threaten ground water by leaching of nutrients and by landfill of incinerator ash.

(4) Life History

As a Level one plan, little contribution is made to niche specialization, a larger size organism or more complex life cycles which are characteristic of stable ecosystems.

(5) Selection Pressure

With heavy emphasis on land treatment, this plan is not compatible with feedback control of populations and may enhance nuisance organisms as the ecosystem is disturbed. It promotes control of pathogens in the land filter.

(6) Overall Homeostasis

Homeostasis refers to the ability of the ecosystem to resist outside disruption. This plan will maximize organism relationships, interfere least with successional development, moderately promote rehabilitation of strip mined areas (42% sludge), generate some harmful aerosols by incinerations, and provide for extensive, but <u>not</u> the most, disturbance and interconversion of terrestrial ecosystems (land use). As a plan emphasizing land treatment it provides moderate protection from the cumulative effects of toxic metals and other chemicals.

c. Resource Demands

Plan 6 will require 1926 megawatts per day for the provision of treatment split about equally between secondary and tertiary. At a current price of $0.0121 per KWH, the daily cost will be $23,305.00. The chemical requirements for the combined treatment systems will be 287,500 pounds per day of lime, ferric chloride, chlorine, alum, and polymers and will cost about $7,681.00 per day at current prices. The future environmental and economic costs of both energy and chemical resources are discussed in an attachment to this report.

d. Reliability

Plan 6 is a combination plan with emphasis on land treatment. It combines the reliability factors mentioned in Plan 1 for the water based plants in the middle basin areas, and those discussed in Plan 2 for the land treatment aspect. Again, the application rate of 90" annually in certain sections of the Rocky River Basin and in the Chagrin River Basin, requires demonstration of its effectiveness.

e. Land Use Changes

Plan 6 emphasizes land in a combined land/water based treatment system and thus relates to most of the previously mentioned land use considerations of land treatment plans (Plans 2, 4). In-Basin acreage requirements are 14,300 acres plus stormwater detention and winter storage. Should high rate application prove ineffective, more land may be required.

f. Public/Political Perceptions

Plan 6 is essentially related to the consideration of political

and public perceptions as elaborated in Plan 2, since the degree of regionalization of plant and the acreage requirements in the basin for land treatment are nearly parallel. Plan 6 does utilize less western land due to its combined land/water treatment design, but institutional factors discussed for western land treatment are still relevant.

g. Flexibility

As a combination plan, Plan 6 combines considerations mentioned in Plans 1 and 2. The most obvious lack of flexibility would be incurred in the building of an effluent tunnel which would commit the lower basin to land-based treatment for the life of the project.

h. Stormwater Management

This is a Level One plan and conforms generally to the treatment discussed in Plan 1. The effluent will be treated and released locally in the upper and middle basins. Lower basins may be carried to the effluent tunnel.

i. Hydrologic Effects

While wastewater will be transferred from the Three Rivers Basin to the west, neither the volumes nor the effect on stream regimens will be pronounced in either basin. The transfer of some 320 mgd will come from the lower basin and the shoreline plants, and will not affect the other stretches of the rivers. The hydrologic effect in the western river basins will be about half of that discussed in Plan 2.

j. Residuals

The residuals from the secondary treatment plants include 681 dry tons of sludge per day (248,565 annually). Stormwater detention and treatment will produce about 131,000 tons per year, largely from sedimentation, for an average of 360 tons per day for disposal. The effluent from the secondary plants will carry substantial loads of nutrients.

k. Disposal Methods

Since about 50% of the sludge is incinerated, the same costs and deficiencies apply to this fraction as are discussed in Plan 1. The costs for application to agricultural lands or in the reclamation of strip mined areas will lie in the transmission and the continuing management required. Reuse opportunities relate to power plant cooling and nutrient recycling.

7. Plan 7, Level Two, Combination Land/Water Based

a. General Features

This plan divides the Three Rivers Basin into three areas: upper, middle and shoreline/lower basin. Upper basins have lower density development, available open space, and limited sanitary sewage. Effluent will be used on local land following secondary treatment. Middle basins are more densely populated, have little open land and will use AWT plants for tertiary treatment. Lower basin and shoreline plants currently discharging to Lake Erie would use tertiary treatment with discharge to the Lake. Separate stormwater would receive secondary treatment and release to land or AWT with release to water.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	6	3S,3T	6	643
Chagrin River	6	5S,1T	7	3,067
Cuyahoga River	12	8S,4T	12	3,743
Lake Erie	5	T	4	
Total	29		29	7,453

(1) Sludge Disposal

Concentration, stabilization and transmission to stripmines 53%

Holding, concentration, incineration and disposal to landfill 44%

Concentration, stabilization, disinfection and land treatment 3%

(2) Facilities Required

Land treatment and winter storage requirements for both domestic and stormwater runoff will take about 7,500 acres. Thirteen sub-basins will receive land treatment and will require winter storage areas. Detention sedimentation basins will be required for 7645 mg

of stormwater runoff, with basins being treated by land or separate stormwater plants, sized for the one year storm. Basins discharging to sanitary plants will be sized for a 30 day capacity, about 16% of the annual runoff.

(3) Special Features

The plan emphasis is on water-based treatment with only 2.3% of the effluent going to land treatment. There is some reuse of current plant capacity for stormwater treatment, six plants being converted. There is limited opportunity for nutrient recycling and stream flow maintenance in upper reaches of the basin. The expansion of the Cleveland water system to serve areas in the basin now dependent on stream diversion has been suggested in some versions of this plan. Such extension would help restore a more natural stream flow, assure a dependable supply and make additional reservoir capacity unnecessary.

b. <u>Ecological Considerations</u>

The ecological advantages and deficiencies relate to the amount of land or water based disposal, the level of treatment and the way in which residuals are disposed of or recycled. As a combination plan, with emphasis on water-based disposal of effluent, the deficiencies in tertiary treatment will be mitigated by the amount of land treatment and vice versa.

(1) Community Energetics

As a plan emphasizing water based treatment, Plan 7 uses major amounts of chemicals and energy, primarily for tertiary treatment. It contributes little to a stable P/R ration (functional index of the stability of the ecosystem), does not promote complex food chains, returns some 50% of sludges to stripmines and requires a moderate expenditure of energy to manage the residuals.

(2) Community Structure

As a Level Two plan, this provides most encouragement to aquatic diversity, to organized communities and to species with a narrow tolerance of change. It minimizes biotic storage of plant nutrients.

(3) Nutrient Cycling

The plan has a minimal recycling of nutrients, minimizes biological control of nutrient cycles, use part of the sludges as soil reconditioners but generates large amounts of inorganic sludges. It provides considerable disturbance to hydrologic regimes but only moderate threat to groundwater quality.

(4) Life History

As a Level Two plan it encourages niche specialization, a larger size of organism and longer, complex life cycles that are characteristic of mature ecosystems.

(5) Selection Pressure

This plan is moderately compatible with feed back control of populations and control of nuisance organisms. At Level Two, there is greater control of pathogens but less than a land plan.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist the disruption of outside influences. With a minor land increment the plan provides minor encouragement to organism interrelationship, ecosystem successional development and provides some land rehabilitation (53% sludge). It will generate some air pollution (44% incineration), and requires least land disturbance or interconversion (water storage). With its limited land treatment it provides minor protection from the cumulative effects of toxic metals and other chemicals.

c. Resource Demands

The electrical power requirements for tertiary treatment amount to 2,171 megawatts per day, with a cost of $26,269 at a current price of $0.0121 per KWH. The chemical requirements, largely for tertiary treatment, include major amounts of chlorine, lime, alum and methanol, a total of 808,540 pounds per day, which would cost at 1972 prices the sum of $96,673.00. The future costs, both economic and environmental, of energy and necessary chemical resources are discussed later in this report.

d. Reliability

Plan 7 combines Level Two, water based treatment with a small increment of land treatment in the upper basins. The reliability characteristics, particularly those describing combined treatment of wastewater and stormwater, in Plans 3 and 4 apply.

e. Land Use Changes

Plan 7 parallels plan 5 in consideration of land use changes for a combined land/water treatment system emphasizing water. Level Two criteria for effluent in Plan 7 may result in some general impacts such as improved development opportunities for water-enhanced land use activity.

f. Public/Political Perceptions

Institutional factors relevant to Plan 7's combined land/water treatment again parallel Plan 5. The response to the major increase in costs for Level Two treatment will depend on the level of public concern for the environment and the phasing of the incremental cost above Level One treatment.

g. Flexibility

As plans reach Level Two, the cost of conversion from one system to another becomes impossibly large, except at the end of the productive life of the plants concerned. There must be considerable concern for the lack of flexibility in phasing sanitary plants if stormwater treatment is to be combined. Reference is made to this section in Plan 3.

h. Stormwater Management

Level Two stormwater treatment is discussed in Plan 1. The questionable characteristics of treating stormwater in the same plant as municipal sewage are discussed in Plan 3.

i. Hydrologic Effects

Although there is some regionalization of stormwater treatment, the use of local land treatment in the upper basin and the greater use of separate stormwater plants mitigate the effect on stream flow.

j. Residuals

The residuals from Plan 7, largely from tertiary plants, will total about 915 dry tons per day, for an annual problem of 334,000 tons. Stormwater detention and treatment will produce about 137,000 tons per year. The limited secondary effluent will provide nutrients for recycling.

k. Disposal Methods

The costs and benefits resulting from the 44% incineration of sludge, the use of effluent for nutrient recycling, and sludge for stripmine rehabilitation are indicated in Plans 1 and 2.

8. Plan 8, Level Two, Combination Land/Water Based

a. General Features

Plan 8 is a combination plan with major emphasis on land treatment of secondary effluent. In plant location it is comparable to Plan 7. However, shoreline plants will discharge to the effluent tunnel to the western lands and additional use is made of land treatment in middle basin areas. Only Akron, North Olmsted and Tinkers Creek plants provide tertiary water-based treatment. Otherwise domestic, compatible industrial, combined and separate sewage receive secondary treatment before land treatment. Secondary treatment for separate stormwater may be in an aerated lagoon, followed by microstraining, long term storage (winter) and chlorination.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	8	7S,1T	14	5,470
Chagrin River	7	S	7	5,754
Cuyahoga River	14	12S,2T	14	17,047
Lake Erie	5	S	6	--
Total	34		41	28,271

(1) Sludge Disposal

Concentration, stabilization, transmission to strip mines 60%

Holding, concentration, incineration and disposal to landfill 35%

Concentration, stabilization, disinfection, and land treatment 5%

(1) Facilities Required

Land treatment and winter storage requirements for both domestic and stormwater runoff will take about 28,000 acres in

the basin, with an additional increment of 1,200 to 1,500 acres being required for stormwater detention of 7,300 million gallons. Basins to be treated on the land or by separate stormwater treatment plants will be sized for the one year storm. Basins being treated with the wastewater system will be sized for 30 day storage, approximately 16% of the annual runoff. The effluent tunnel will be sized for over 600 mgd, requiring about 130,000 acres in North Central Ohio for land treatment and additional for winter storage.

(3) Special Features

With only three water-based tertiary treatment plants discharging to the middle reaches of the Rocky and Cuyahoga Rivers, this plan is the most land oriented of any combination system. Opportunity exists for a variety of reuse options, including industrial cooling, power plant cooling and flow augmentation in all rivers.

b. Ecological Considerations

(1) Community Energetics

Plan 8 requires the input of moderate amounts of power and chemicals, contributes toward a stable P/R ratio (functional index of the stability of the ecosystem), in its land aspects, and moderately promotes food chain complexity and the return of humic materials to the soil. It will require major inputs of labor and energy to manage the residuals.

(2) Community Structure

To the extent that land treatment is used, and effluent is withheld from the streams, the plan provides encouragement to a

diversity of aquatic life, to highly organized communities, and to species with a narrow tolerance to enviromental factors, all evident in a stable ecosystem. The plan provides for major biotic storage of nutrients.

(3) Nutrient Cycling

The plan provides for major recycling of nutrients with biological control, fewer inorganic sludges, but with greater disturbance to stream regimes and more threat to ground water pollution.

(4) Life History

As a Level Two plan, niche specialization, larger organisms and longer, complex life cycles are encouraged. All are characteristic of mature, more stable aquatic ecosystems.

(5) Selection Pressure

This plan is least compatible with feedback control of aquatic populations and control of nuisance organisms, but will promote greater control of pathogens in the aquatic ecosystem.

(6) Overall Homeostasis

Homeostasis refers to the ability of the ecosystem to resist the disruption of outside influences. Plan 8 encourages mutualistic relationships among organisms, interferes least with natural successional development and promotes major rehabilitation of disturbed ecosystems. It generates limited amounts of harmful aerosols (35% incineration) and requires major land disturbance and inter-conversion to aquatic ecosystems. The land component provides best protection of life from the cumulative effects of toxic metals and other chemicals.

c. Resource Deamnds

Power requirements for treatment amount to 1900 megawatts per day, currently costed at $0.0121 per KWH for a total of $22,990. Chemical requirements total 285,000 pounds of chlorine, lime, ferric chloride, alum, polymers, and methanol, for an estimated daily current cost of $27,660. Consideration of the future environmental and economic costs of resources are discussed in an attachment to this report.

d. Reliability

Plan 8 combines a Level Two land treatment system with three tertiary plants discharging to water (North Olmsted, Tinkers Creek and Akron). The reliability factors for land based and water based systems are indicated in this section of Plans 3 and 4 and will not be repeated here. However, note must be taken of application rates, 90 inches for secondary effluent and 150 inches for storm water, particularly in the Rocky River basin, with the observation that the effectiveness of land treatment at these rates is still to be demonstrated. In addition, the establishment of a winter storage period of only 12 weeks, when compared to long term freezing records, seems overly optimistic.

e. Land Use Changes

Plan 8 is similar to Plan 6 in that its land use relates to an emphasis on land treatment. However, more than 10,000 additional acres are required in-basin, with as much as 1,500 acres being converted to detention ponds for stormwater. Should projected application rates in several of the basins prove optimistic, additional

land will be required. Land will be required for transmission of the effluent to North Central Ohio, and, depending on the acquisition and management of agricultural land, can either be highly disruptive of current patterns or supportive. The transmission and application of sludge to stripmined lands can only have beneficial consequences for that vandalized land.

f. Political/Public Perceptions

The institutional and public problems of Plan 8, will be largely related to land use, even though the plan is a combination. In this respect it will encounter the problems outlined in Plan 2, plus increased land use within the basin and the increased costs related to Level Two treatment. These factors are expected to magnify the difficulties in obtaining public acceptance and political accommodation. Plan 8 does use less western land than Plan 2, due to the portion water-based, but the exact amount of land is not seen as critically significant. The acceptance will depend on the acceptance of wastewater as a resource, together with a continuing public understanding and concern with environmental issues, including our diminishing resources.

g. Flexibility

The conversion of land plans in-basin to other treatment methods is readily possible since land can revert to other uses with no diminution of value. Land can also respond to variations in wastewater flow far more readily than a tertiary plant designed for a

specific peak level. At such time as the major commitment of an effluent tunnel must be made, there can be little room for plan amendments or phasing. The effluent tunnel will commit the system to land treatment for the life of the project, or the foreseeable future, because of the capital cost involved.

h. Stormwater Management

The level of stormwater treatment is discussed in Plan 1. The questionable aspects of treating stormwater with municipal sewage are discussed in Plan 3. Otherwise the treatment aspects are discussed in Plan 4.

i. Hydrologic Effects

Plan 8 again proposes a major interbasin transfer of wastewater. The hydrologic effects are not severe as in Plan 4 since the 500 mgd comes from the lower basin and shoreline plants. Upper basins using land treatment are generally unaffected while middle basin plants discharge either to adjacent land or water. While regionalization is indicated in stormwater treatment, the 41 stormwater treatment plants provide good distribution of the return flow. The hydrologic effect on out-of-basin streams is discussed in Plan 2.

j. Residuals

The treatment plant residuals include 628 dry tons of sludge daily, or about 230,000 tons per year. The residuals from stormwater treatment, largely sedimentation, amount to over 142,000 tons per year. The effluent from the secondary plants will carry plant

nutrients. The residual from the tertiary plants will include a considerable amount of non-organic sludges from chemical treatment.

k. Disposal Methods

Plan 8 projects the use of a major amount of the secondary sludges for use in the reclamation of Ohio stripmined areas. The cost for transmission of sludges to some disposal point is one that must be borne in any event, and the possibility of the use of an old coal slurry pipeline from the Lake to Harrison County is fortuitous.

Since several state agencies and commissions have responsibility for the reclamation of stripmined land, the management of this resource may well be delegated to them. The transmission and management of the nutrient-rich effluent, may potentially be either a government responsibility, or one that can be contracted to private farm operators. The transmission costs might well be higher under a private contract arrangement, but the social and economic disruption would be less. In agricultural application, the crop residual must be considered if government managment is used. The possibility that the U.S. agricultural surplus is a thing of the past, and that major changes may be taking place in the national agricultural establishment, cannot be discounted. If a realistic resource policy is adopted, all secondary effluent may be in demand.

9. Plan 9, Level Two, Combination Land/Water Based

a. General Features

Plan 9 is a highly regionalized system providing only eleven plant locations in-basin. Four shoreline plants will be converted to provide only primary treatment for domestic/industrial sewage and stormwater before discharge to the effluent tunnel. This sewage will be treated in North Central Ohio in aerated lagoons before use for irrigation of adjacent agricultural lands. Other plants are tertiary, water-based with the exception of two small land-based plants in the upper Cuyahoga basin. Underground storage is provided for combined overflows in advance of tertiary treatment while separate urban storm flows are stored for release and treatment in off-peak hours of sanitary sewage plants.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	1	T	--	
Chagrin River	1	T	--	
Cuyahoga River	5	2S,3T	--	2,500
Lake Erie	4	P	2	
Total	11		2	2,500

(1) Sludge Disposal

Holding, concentration, incineration, disposal to landfill 58.5%

Direct land application after pumping from aerated lagoon 41.5%

(2) Facilities Required

Land treatment and winter storage will require about 2500 acres in the upper Cuyahoga basin. Detention storage ponds for urban run-off will require about 2100 acres. Nearly 10,000 million gallons will require storage, largely designed for 30 day capacity, for flow

equalization before release to the tertiary plants for treatment. Western land treatment will require some 62,000 acres, with additional lands for winter storage and for aerated lagoons.

(3) Special Features

While limited stream management possibilities exist in the Upper Cuyahoga, all stormwater and sewage flows are completely collected in other areas, removing flow from streams and resulting in extensive transmission lines to regionalized plants.

b. Ecological Considerations

(1) Community Energetics

Plan 9 consumes relatively little power but large amounts of chemicals, principally for tertiary treatment. It makes moderate contributions toward a stable P/R ratio, (functional index of the stability of an ecosystem) complex food chains, and return of humic materials to the land. It will require extensive human and mechanical input to maintain stability in the receiving ecosystems.

(2) Community Structure

The plan encourages diversity of aquatic life, highly organized communities and species with a narrow tolerance of change, all normally evident in a stable ecosystem. It provides opportunity for some biotic storage of plant nutrients.

(3) Nutrient Cycling

The plan provides for about 40% recycling of nutrients. It moderately encourages biological control of nutrient cycling, generates moderate amounts of inorganic sludges and will exert major influence on hydrologic regimes in the basin by removing stormwater. The potential threat to groundwater quality, by loss from aerated lagoons and by leaching of nitrogen is high.

(4) Life History

Within the aquatic ecosystem, the plan will foster niche specialization, a larger size of organism and longer complex life cycles, all characteristic of mature stable ecosystems.

(5) Selection Pressure

Within the aquatic ecosystem, this plan will provide least feedback control of population growth and will potentiate growth of nuisance organisms such as mosquitoes, midges and aquatic weeds and algae. While land treatment tends to provide better control of pathogens, the aerated lagoon system elements may limit this efficiency.

(6) Overall Homeostasis

Homeostasis refers to the ability of the ecosystem to resist disruption caused by outside influences. Plan 9 maximizes organism interrelations and natural successional development, promotes minor rehabilitation of disturbed ecosystems, generates some potentially harmful aerosols by incineration and requires moderate disturbance of terrestrial ecosystems and some interconversion for both aerated lagoons and winter storage. The question of the protection of plant, animal and human life from cumulative effects of toxic metals normally is resolved in favor of land treatment. However, without chemical flocculation applied in an aerated lagoon system, greater flow through must result as compared to an activated sludge secondary and less than full credit must be allowed on this basis.

c. <u>Resource Demands</u>

The power requirements in Plan 9 amount to 1200 megawatts per day, primarily for plants providing tertiary treatment. No power costs are included in this total for effluent tunnel transmission or aeration or for the power costs of aeration within lagoons. The current cost at $0.0121 per KWH will be $14,520 per day. Chemical requirements, also largely for tertiary treatment, amount to 532,000 pounds and a current estimated cost of $59,155 per day. Reference is made to the attached paper on future environmental and economic costs of resources.

d. <u>Reliability</u>

Plan 9 is a combination plan that reverses the usual order in that upper and middle basins use tertiary treatment and discharge to water while four shoreline plants will provide only primary treatment and discharge minimally treated raw sewage to the effluent tunnel. The reliability aspects of water based plants are discussed in Plan 3. The transmission of raw sewage over long distances may well create conditions inimical to the pipe structure. The high BOD temperature and the long travel time can create septic conditions leading to sulfide evolution in addition to the obvious sulfate corrosion. The effect of these products when discharged need consideration. Under these circumstances the reliability of single pipelines and pumping arrangements is open to question. The lack of alternatives to dumping raw sewage in the lake in case of failure of transmission is distressing. The reliability of the aerated lagoon to produce secondary quality effluent under all conditions, few of which are under control of the operator, must be questioned.

Reference is made to the attached discussion of aerated lagoons and to the land questions in Plan 2.

e. Land Use Changes

Plan 9 requires 2,500 acres for land treatment and storage in the Upper Cuyahoga Basin, plus pretreatment storage space. Western land treatment and storage requires about 62,000 acres plus space for aerated lagoons and winter storage. Nearly 60% of the sludge will be incinerated, requiring landfill space on isolated acreage in the basin.

The problems noted in several preceding discussions of land use changes (Plans 2 and 4) will be exacerbated in Plan 9. Although the in-basin land use is relatively small, the transmission of raw sewage from the shoreline plants to western agricultural areas constitutes a shift in the quality of the land use proposed. The highly regionalized character of the plan will require long transmission lines within the basin, involving rights-of-way and the removal of flow to a critical degree from some tributaries, which of itself will affect land uses and values adjacent to these streams.

f. Political/Public Perceptions

An environmentally desirable plan for the treatment of wastewater in the basin involving the reuse of the nutrients that are present, will depend in large measure upon the public image that can be generated in support of a plan to transmit these resources to the land. It must be questioned, whether the added burden of the transmission of raw sewage, and the use of aerated lagoons, can be added to the interbasin transfer and the use of large amounts of agricultural land in North Central Ohio, and still remain a politically

viable plan. Other institutional factors apply that have been discussed in Plans 2 and 4.

g. Flexibility

As a Level Two plan, the options within the basin will be just about used up with the installation of tertiary plants. The flexibility of water based treatment is discussed in Plans 1 and 3. The use of only primary treatment at shoreline plants requires a phasing out of other treatment methods but leaves the door open for later plant construction related to land use options. The construction of the effluent tunnel limits any other approach. The transmission of sewage with only primary treatment will limit the use of the effluent for once through cooling for shoreline power plants. Other questions must be raised regarding the use of effluent from aerated lagoons for power related cooling due to the potentially high algal content.

h. Stormwater Management

The discussion of stormwater treatment levels in Plan 1 and Plan 3 generally apply to this plan as well. Runoff will be collected, stored and conveyed to very few tertiary treatment plants for treatment in the hydrologic valley of the sanitary sewage treatment. The questionable efficiency of this plan is discussed in Plan 3.

i. Hydrologic Effects

The most significant hydrologic effect in this plan is the combination of stormwater treatment at five plants in the basin. The diversion of stormwater downstream to regional plants will reduce the flow in several reaches of streams and may completely dry up some of the smaller tributaries. The interbasin transfer will not have an additional effect since only shoreline plants are

involved. Less than 300 mgd are being transferred and the effect on the western areas are less than half of that discussed in Plan 2.

j. Residuals

Residual sludges from tertiary treatment will be handled by incineration and the balance disposal to landfill. About 114,000 tons of sedimentation will be recovered yearly from the stormwater collection basin. The sludges produced in the facultative sections of the aerated lagoons will be dredged hydrualically and pumped to adjacent agricultural lands.

k. Disposal Methods

The costs generated by disposal include incineration costs indicated in Plan 1 and the transmission and continued management costs for sludge and effluent application.

10. Plan 10, Level Two, Advanced Biological

a. General Features

Plan 10 provides a "pure" advanced biological treatment plan based on the same plant sizing and location as in Plan 3. The basic activated sludge process is upgraded by adding ammonia oxidation (nitrification), adding alum for phosphate removal, denitrification of organic nitrogen using methanol, the addition of organic polymers and filtration for solids removal, and finally a carbon adsorption system for removal of refactory organics with the carbon regenerated. If necessary to meet reuse standards, a reverse osmosis process would also be added. All stormwater runoff will be treated after detention storage for flow leveling.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	7	T	--	For Stormwater
Chagrin River	7	T	--	Detention Only
Cuyahoga River	10	T	--	
Lake Erie	5	T	--	
Total	29			2,100

(1) Sludge Disposal

Concentration, stabilization and transmission to stripmines 95%

Concentration, stabilization, disinfection, land treatment 5%

(2) Facilities Required

All discharges are to water, therefore no winter storage is required. However, stormwater collection and holding basins will require about 2100 acres.

b. Ecological Considerations

Plan 10 being an all water based, advanced biological, Level Two plan, has all the ecological impact of Plan 3. The major exception is in sludge handling which places 5% into local land treatment and 95% to strip mines reclamation, thereby improving Plan 10's ecological rating. Reference is made, therefore, to the ecological evaluation of Plan 3.

c. Resource Demands

Plan 10 will require the input of 2460 megawatts of power per day for carbon adsorption, aeration, denitrification, mixing and primary treatment. The power cost per day at $0.0121 per KWH will amount to $29,766. The chemical input of 833,000 pounds of lime, chlorine, alum, polymers and major amounts of methanol will cost an estimated $98,025 at today's prices. The process loss of carbon in regeneration has not been included. Future cost considerations are reviewed in an attachment to this report.

d. Reliability

Plan 10 uses the plant configurations and methods of Plan 3. Reference is made to the discussion under the reliability section of Plan 3 for this and for the discussion of Land Use Changes, Political and Public Perceptions, Flexibility, and Stormwater Management. The effluent flows and Hydrologic Effects are also identical. The residuals include 923 dry tons per day of sludges and 132,000 tons per annum of sediment from stormwater detention basins. The usual cost of disposal relative to stripmine and agricultural land disposal are also indicated.

11. Plan 11, Level Two, Advanced Physical/Chemical

a. General Features

Plan 11 provides a "pure" advanced physical/chemical treatment plan based on the plant sizing and location as in Plan 3. The basic physical/chemical system incorporates lime coagulation and clarification, recarbonation, filtration and carbon adsorption. This is upgraded by a second stage clarifier for phosphorus removal, breakpoint chlorination for ammonia nitrogen removal, additional carbon adsorption and final ozonation. All products are incinerated to ash in the process of regeneration of lime and carbon. All stormwater runoff will be treated after detention storage for flow leveling.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	7	T	3 T	325
Chagrin River	7	T	---	182
Cuyahoga River	9	T	3 T	737
Lake Erie	5	T	---	57
Total	28		6	1301

(1) Sludge Disposal

Dewatering, reclamation and ash to landfill 100%

(2) Facilities Required

As in Plan 10, all discharges are to water, therefore no winter storage is required. Stormwater collection and detention will require 2100 acres for 136 basins.

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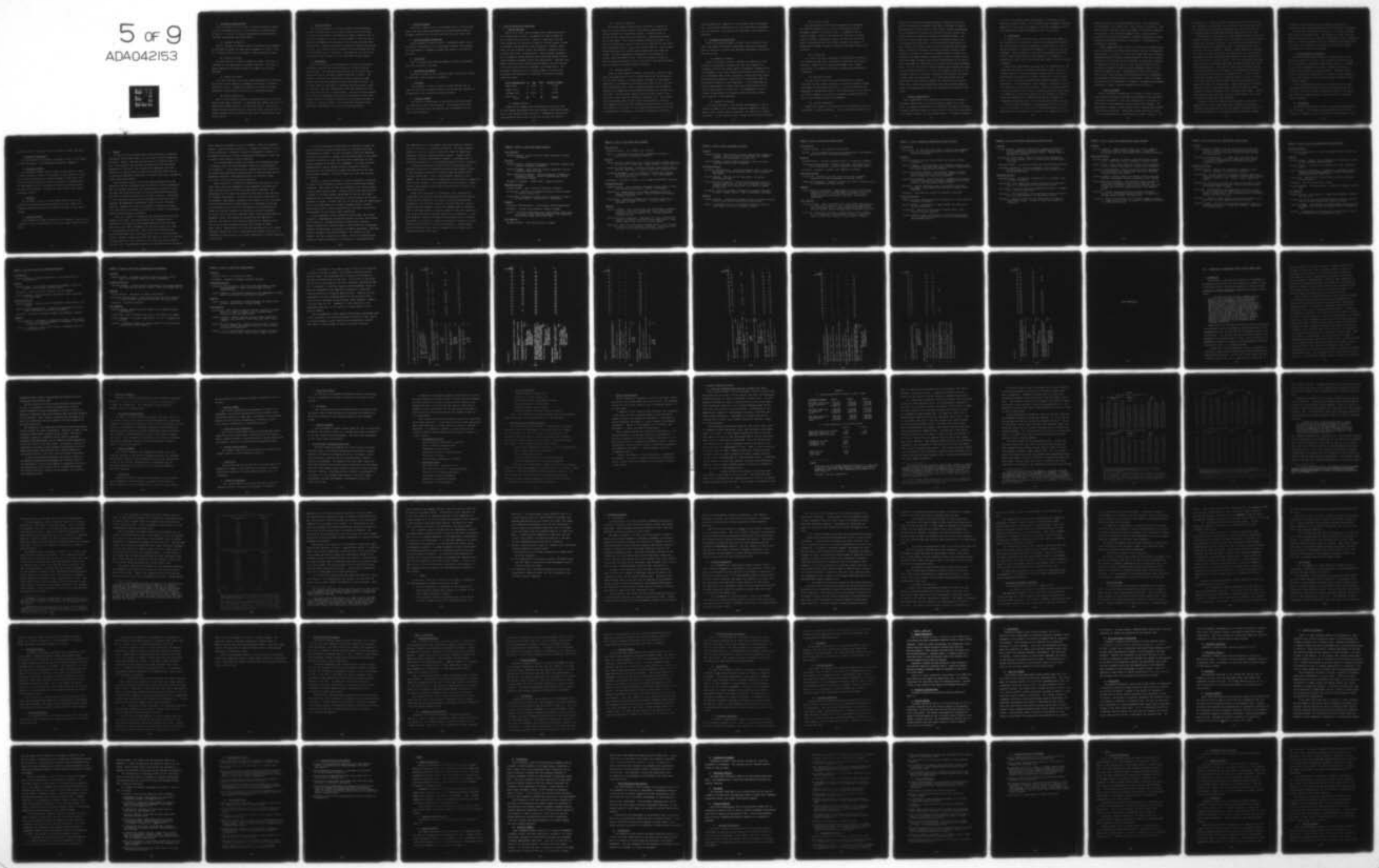

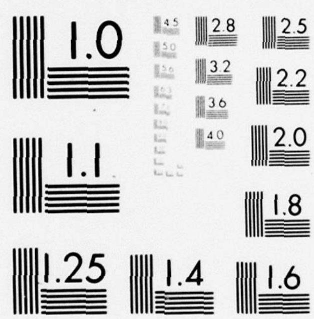

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b. Ecological Considerations

Plan 11, based as it is on Plan 3, and providing water-based, Level Two treatment, has most of the ecological characteristics of Plan 3. It differs in several significant sections however, and these sections are considered below.

(1) Community Energetics

Plan 11 consumes the largest amount of resources for treatment of any plan and equals the high power consumption of Plans 3 and 10. No humic materials are returned to the ecosystem of origin.

(2) Nutrient Cycling

The plan provides no organic sludges for reuse, all being incinerated in the regeneration of process chemicals. The plan, of course, generates the highest amount of sludges with no reuse potential.

(3) Selection Pressure

As a Level Two plan, with final carbon adsorption and ozonation, the control of the release of pathogens to the water is probably better than Plan 3, although the regrowth of bacteria in carbon adsorption columns must be considered as a potential problem.

(4) Overall Homeostasis

Plan 11 does nothing to promote the rehabilitation of the strip-mines or any other ecosystem. It generates the largest quantities of potentially harmful aerosols, far more than Plan 3. The physical-chemical process provides better removal of metals and chemicals and thereby provides better protection than Plan 3 from potential cumulative effects.

c. Resource Demands

The power requirements for Plan 11 amount to 2460 megawatts per day, costing $29,766 at the current rate of $0.0121 per KWH. The chemical requirements constitute the largest volume per day of any plan although not of cost. Massive amounts of chlorine are required for breakpoint chlorination as well as lime, calcium oxide and polymers. Transportation and/or storage of chemicals may become critical. The chemical use will amount to 1,925,000 pounds per day at an estimated cost of $50,989.00. Consideration of future costs of power and other resources is discussed later in this report.

d. Reliability

Plan 11 is based on the configuration of Plan 3 but discards biological secondary and tertiary steps for a "pure" physical-chemical plan. The treatment indicated has yet to receive major application and is therefore somewhat difficult to assess. The system is certainly not susceptible to shock loading and other factors that make the biological process unreliable at times. On the other hand its efficiency in removing certain products, metals for instance, and then releasing them into the regeneration stack gas to pollute the air, is questionable. The use of massive amounts of chlorine for breakpoint chlorination and nitrogen removal adds massive amounts of dissolved chlorides to the effluent and must be counted as a negative aspect. The reliability evaluation needs additional investigation of the most recent applications.

e. Land Use Changes

Reference is made to this section under Plan 3, with the additional note that space requirements for receiving and storage of treatment chemicals will be more than four times any other plan.

f. Political/Public Perceptions

Again reference is made to Plan 3. Additional public resistance might be generated by air pollutional problems, the disposal of large amounts of inorganic sludges and failure to recycle the nutrients.

g. Flexibility

Plan 11, using "pure" physical-chemical plants is considered the least flexible of any plan.

h. Stormwater Management

Reference is made to this section of Plan 3 and to the section on Hydrologic Effects which are identical.

i. Residuals

The residuals in Plan 11 consist of about 682 dry tons of waste ash from the reclamation furnace and 132,000 tons annually of sedimentation from stormwater collection basins.

j. Disposal Methods

The costs of incineration, air pollution, and land disposal are unalloyed by any reuse potential. Its principal deficiency must be characterized as the greatest use of resources for the least reuse potential.

12. Plan 12, Level Two, Land Based

a. General Features

Plan 12 is a "pure" land treatment plan, generally based on the configuration of Plan 4, but adding the land treatment of Akron sewage within the basin. Domestic, industrial, and combined sewage will be collected, treated in aerated lagoons, stored as necessary, and applied for land irrigation. Separate stormwater will be collected, stored, and applied to adjacent land at an annual 150" over a 40-week period. Other separate stormwater may be handled by 30-day detention and processing through aerated lagoon secondary treatment before land application. Combined storm runoff basins will have 3-day detention capacity and will release to the collection system for treatment in off-peak hours. All secondary treatment will be by aerated lagoon. The plan also anticipates the acceptance of untreated, or partially treated, industrial wastes.

Plant Configuration	No.	Type	SWTP	Acreage in Basin
Rocky River	8	6S,2P	12	4,856
Chagrin River	6	S	12	5,519
Cuyahoga River	15	14S,1P	21	42,390
Lake Erie	5	P	1	
Total	34		46	52,765

(1) Sludge Disposal

Sludge will be pumped from the facultative section of the aerated lagoons and applied with deep plowing in the western lands, and by other methods within the basin. Sedimentation from stormwater detention basins will be used for top soil and landfill.

(2) Facilities Required

The aerated lagoon system proposed indicates a sequence of deep (15-20 feet) aerated lagoons, providing a completely mixed system, followed by a facultative lagoon. Detention times of 3.3 and 10 days respectively are indicated. Chlorination follows the second lagoon. Slow speed mechanical aerators are used. Extensive utilization of land in basin will be required for land treatment, detention, winter storage, and aerated lagoons. Certain application techniques will require public ownership of the land concerned. The plan contemplates replacement of all plants by an aerated lagoon treatment system. Since raw sewage is being conveyed to western agricultural areas, aeration of the effluent tunnel will be required to prevent sulfate corrosion.

(3) Special Features

There are many unusual techniques and features covered in this plan, including the sole use of aerated lagoons and the phasing out of all current plants. The application technique of "Mini-Border/ Open Space" is introduced, with application rates of up to 150" per year on Mahoning soils. Other irrigation methods are introduced, together with suggested farm management techniques for varying soils and crops. The mini-border application will require public ownership of the land, and will exclude any alternate use. The potential of using storage ponds as power plant cooling ponds is explored. Flow augmentation in both the Cuyahoga and Rocky Rivers is indicated. Flow control of the rivers in the North Central Ohio land areas will be accomplished by storage of the filtered effluent in reservoirs,

located generally as suggested in the Northwest Water Development Plan. Recreational opportunities are also indicated in accordance with the same plan. Recycling of all nutrients in the effluent is indicated.

b. Ecological Considerations

While the ecological impacts of Plan 12 are related to other plans, the number of innovative departures from other land plans tends to establish a picture with distinct differences unrelated to the land in use.

(1) Community Energetics

Plan 12 is unique in that it consumes no chemicals or other resources for municipal treatment and only minor amounts for stormwater and that the energy input for treatment (transmission is not included) is less than a third of the twelve plan average. It will contribute highly toward achieving a unitary P/R ratio (gross production/total community respiration is a functional index of the relative maturity of the ecosystem). It will moderately promote the development of complex food chains and maximize the return of humic materials to the soil. The management of the residuals in agriculture will require effort and energy to maintain stability in the ecosystem.

(2) Community Structure

As a Level Two plan it will provide encouragement to the diversity of aquatic life, to highly organized communities, and to species with a narrow range of tolerance, all typical in a stable ecosystem. It will maximize biotic storage of major plant nutrients.

(3) Nutrient Cycling

The plan maximizes recycling of phosphorus and nitrogen, the reuse of organic sludges as soil conditioners, and the biological control of nutrient cycles. It generates few inorganic sludges. However, the plan may be expected to disturb current (natural?) hydrologic regimes, and may from aerated lagoons, land applications, and storage, threaten the quality of ground water through leaching of nutrients and other chemical constituents.

(4) Life History

As a Level Two plan, returning a relatively pure effluent to the streams and Lake Erie, the plan will encourage niche specialization, a larger size of organism and longer, more complex life cycles in the aquatic ecosystem, conditions characteristic of maturity.

(5) Selection Pressure

The plan will provide least selection pressure in aquatic ecosystems and may promote outbreaks of nuisance organisms through disturbance to the present ecosystem. It may also allow disease organisms to spread more rapidly. The effectiveness of the land filter may be hampered by the type of secondary treatment which permits a less effective removal of pathogens.

(6) Overall Homeostasis

Homeostasis refers to the ability of an ecosystem to resist the disruption of outside influences. Plan 12 maximizes mutualistic or

synergistic relationships among organisms, interferes least with natural successional development, but makes no attempt to promote rehabilitation of strip mines or other areas. Without incineration the plan generates no chemical air pollution but may produce some aerosol effect in mechanical aeration of treatment lagoons. The plan will require large areas of land for treatment purposes and will provide most disturbance to the terrestrial ecosystem and require conversion of large areas of land into treatment and storage ponds. The use of filtration following secondary treatment would normally be expected to sequester or degrade metals or other toxic chemicals that might otherwise accumulate in plant or animal tissue. Activated sludge treatment would remove approximately 80% of metals which then might be transferred to strip mine areas on non-productive soils. Plan 12 will treat in aerated lagoons and transfer the sludge to land in agricultural use. Plan 12 also suggests that due to the treatment capacity of the land, industrial pre-treatment for removal of toxic wastes is unnecessary. This additional burden and the application of the resultant sludges and effluent to agricultural lands, plus conflicting documentation about the selective uptake by plants of hazardous metals, make this land plan less effective than others.

c. Resource Requirements

Power requirements for transmission and mechanical aeration in treatment lagoons give this plan the highest energy cost of any plan. No chemical requirements are calculated for domestic treatment although significant amounts of chlorine will be used for chlorination of the final effluent from the aerated lagoons. Stormwater treatment

in Plan 12 will require about 55,000 pounds of chemicals per day, primarily activated carbon. The variegated land management techniques suggested for this plan also suggest considerable management effort and supplemental energy requirements to make it effective.

d. Reliability

In comparison to all other plans, Plan 12 must rank highest in the introduction of innovative techniques and combinations thereof. The only difficulty with such innovation is that there is less reported experience to confirm the reliability or efficiency of the technique. While a number of criticisms and questions are raised in this section about Plan 12, the intention is to indicate a necessity for small scale field testing and further evaluation before acceptance.

Among these questionable techniques are the transmission of raw sewage from the basin to westerly agricultural lands, the use of aerated lagoons to achieve secondary effluent quality without acknowledging the necessity for extreme flexibility in this climate, and the use of the mini-border/overland runoff technique for land application. The transmission of raw sewage is discussed in Plan 9, and reference is made to that section. The use of aerated lagoons is also discussed in Plan 9 and in a previous section of this report. The inability to control the quality of the effluent, the unusual sizes and sequence of the lagoon system and the influences of temperature on holding times in this climate need further checking.

The mini-border technique is discussed under the next section, but it is necessary to say that the available literature and the experience of the evaluators is contrary to the suggestion of high

application rates on Ellsworth-Mahoning Soils. The method would be exceptional, if it would work. Field testing is essential. Some questions have also been raised with regard to continual irrigation by drip tubes. The literature suggests that a drying period is essential to avoid the development of anaerobic conditions or other conditions that would clog the soil porosity. An adjustment of technique is indicated.

A final suggestion made in Plan 12 is that land treatment eliminates or reduces the necessity and therefore the cost of industrial pretreatment. The soil, it is said, can accept and store virtually unlimited amounts of metals, without toxicity to the soil or plants. Unresolved, in the minds of the evaluators, are questions relating to long-term toxicity in the soil, the selective uptake and concentration of metals by plants and the subsequent transfer to herbivores or humans in food. Investigators at this time are only able to hint at the possible association between soil contaminants (or materials naturally present) and morbidity. There are enough indications of a relationship to oncogenic, teratogenic and mutagenic occurences to make a cautious approach the one of choice.

e. Land Use Changes

Plan 12 minimizes transmission of effluent to western agricultural land by allocating increased land treatment within the Basin, principally from Akron. Thus, over 60,000 acres are required in the basin for land treatment, detention and winter storage. The agricultural acreage in North Central Ohio is substantially reduced from previous land plans. Additional acreage uses, both in-basin and to the west, relate to aerated lagoon secondary treatment. All

considerations of land use changes previously discussed for in-basin land treatment are applicable, with further concern warranted by Plan 12's increased basin acreage requirements and the proposed methods of aerated lagoon treatment and effluent application on the land.

Transmission of raw sewage for aerated lagoon treatment intensifies problems of public acceptance, due to the impact of occasional aesthetic failure and landscape disruption. The mini-border/overland run off technique proposes an application rate to Mahoning-Ellsworth soil of 90 to 150 inches annually. However, should assumptions concerning soil types and application rates be invalidated, the availability of alternate soils and increased acreage required by lower application rates will warrant critical concern. Also, the mini-border technique requires that the treatment land would be publicly owned open space areas and greenbelts. Such land use would provide benefits and restrict urban sprawl, but the proposal is dependent on effectiveness of infiltration of effluent on the chosen soils. If the effluent cannot move through the soil, continuous wetness of the soil during the irrigation period would prohibit any beneficial public use and negatively impact the visual image. Sludge application on Mahoning-Ellsworth soils is also questionable since even digested sludge produces an odor and leaches with a resultant brown liquor. Negative enviromental effects may also occur due to the effects of a wetter ecosystem on plant and animal diversity.

However, if the soil problems can be worked out, the public use potential may satisfy some recreational demands in the region. Potential sites indicated in the Ohio Outdoor Recreation Study and the area designated by the Cuyahoga Park Plan currently pending

in Congress could provide an initial planning framework for coordinating land treatment potential with recreational development.

An additional consideration for Plan 12 is the lack of sludge application on stripmined land. Considering that right-of-way for transmission already exists and that rehabilitation of the vandalized land has a high environmental priority, stripmine application may be considered as an alternative to minimize the extensive acreage requirement of in-basin land treatment.

f. Political/Public Perceptions

If any of the previously discussed considerations of institutional responses to in-basin land treatment are accurate, they can be expected to become more significant in Plan 12. Problems of political accommodation and public perceptions relative to western land treatment are also applicable. Additional factors of Plan 12 which may inhibit public acceptance are the phasing out of all current plants and the possible negative aesthetic impact of aerated lagoons.

It may be mentioned that Plan 12 represents the most significant departure from current wastewater treatment practices in the Basin, at least in terms of innovation visible to the public. Such extensive change may make it more difficult in obtaining public acceptance.

g. Flexibility

The flexibility sections in Plan 2 are generally applicable to this land plan. To the extent that purchase or use of land is essential in advance, and for the basin the large amounts of land

would be critical, the plan is not as flexible as other land plans.

h. Stormwater Management

The effectiveness of stormwater treatment in Plan 12 will depend on the effectiveness of the management techniques suggested.

i. Hydrologic Effects

The hydrologic effects noted in other all land plans (2 and 4) to which reference is made, are mitigated by the reduction in inter-basin transfer indicated by in-basin treatment of the Akron area. The use of major additional areas of the Rocky and Cuyahoga Basins for land application will eliminate the low flow problems caused by other all land plans. Reference is made to Plan 2 for western hydrologic effects.

j. Residuals

The residuals in Plan 12 include about 100,000 tons of sedimentation in stormwater detention annually and the sludge to be dredged hydraulically from the facultative sections of the aerated lagoons.

k. Disposal Methods

Both effluent and sludge residuals will be applied to agricultural lands out of basin and grasslands in the mini-border technique in the basin.

D. Summary

In review of the preceding twelve plan evaluation it should be immediately obvious that there is no one "best" solution among those presented. Rather, each plan has deficiencies or problem areas, as well as constructive and positive contributions to the wastewater management of the basin. The processes and components have been subjected to critical analysis, with the recognition that these can be tested and improved as necessary to achieve a goal and a reliability before final design phases.

Our principal concerns are for the assured protection of the population and the environment from the effects of waste accumulation and its treatment technology, for conservation of resources in both the waste and the process, and for the most advantageous recycling and reuse of nutrients within the accessible ecosystem. Flexibility is to be cherished, along with the consideration that there are few mandated and unamendable requirements within the water resources spectrum. Managerial options in wastewater, stormwater and industrial practices are available, and need to be related to construction options and multi-purpose potential.

There are a number of assumptions and characteristics that are common to all plans. Each plan reflects the assumption that a projected 91.6% increase in municipal/industrial wastewater treatment by the year 2020, including a 20% increase projected by 1980, is an appropriate design base. While industrial wastewater projections anticipate some recycling of water due to cost and process factors, domestic sewage projections anticipate not only a 75% increase in population but a 36.4% increase in per capita wastewater flow by the year 2020. The individual plans do not incorporate water saving or

waste reduction techniques in their strategies, except in stormwater control. Each alternative, therefore, is equally susceptible to error in the design base. Reference is made to Attachment C, Analysis of Wastewater Projections for the Cleveland-Akron Metropolitan Area, for a review of the validity of this assumption.

It is assumed that all plans can achieve the technological goal or treatment level for which designed, though with varying degrees of reliability. It must necessarily be assumed that each system will be operated and maintained by appropriately skilled personnel who are adequately supported, both administratively and fiscally, since this ideal is not characteristically achieved.

Each alternative is expected to improve the water quality of the Three Rivers Basin and, depending on the management techniques pursued, the water quality of the extra-basin areas concerned. The improvement will of course vary with the water quality goal and level of treatment incorporated. All plans will contribute selectively to environmental improvement, sometimes at the expense of other locations by the destruction and re-establishment of an indigenous ecosystem. Each alternative will affect the environment by the expenditure of energy and external resources far beyond any current requirement. All plans collect and treat stormwater runoff with the added effects of dampening floods, the trapping of sediment and the reduction of erosion. The benefit to the natural ecology may be somewhat offset due to the variable discharge patterns which change the hydrologic regime. Opportunities for localized non-potable uses of treated stormwater and the use of the recreational and aesthetic potential of stormwater collection basins, are either undeveloped or totally neglected in all plans.

All of the alternative formulations are designed to manage the entire river basin, using varying degrees of regionalization and consolidation of plants. All will be forced to deal with questions of political feasibility, ranging from the establishment of new administrative structures to cope with basin-wide coordination to even greater problems of sub-state area management. All plans will have extended public impact, whether from the disruption caused by construction, the dislocation of people from the land or the long term taxation incurred. The public impact will vary from one plan to the next.

Finally, it may be indicated, all plans incorporate a potential for reuse of the wastewater resources and for various multi-purpose synergisms. While many of these are developed in the several plans, too many others remain latent. Perhaps the most unfortunate failure to adhere to the multi-purpose philosophy has been in the single minded pursuit of economic efficiency in certain aspects of the land treatment of sewage. Notably these are in certain high rate applications and in the establishment of a sewage treatment enclave in North Central Ohio, both of which effectively bar the public from the use and enjoyment of vast areas of Ohio countryside.

At the beginning of this evaluation section (page 285) eleven categories, comprehending the multiple impacts assessed, were defined. These categories included Ecological Considerations, Resource Demands, Reliability, Land Use Changes, Public/Political Perceptions, Economic Considerations, Flexibility, Stormwater Management, Hydrologic Effects, Residuals and Disposal Methods. For purposes of this Summary, two other categories are added. These are Regionalization which will relate specifically to the degree of consolidation and

the compatibility of consolidation with other aspects of analysis such as stream flow or treatment reliability. The other category added will be Design Features, which will relate to significant departures from the categorical design aspects. Finally, where indicated, a Special, non-specific category is provided, where a particular characteristic of overriding importance may be designated.

As indicated elsewhere in this report, the evaluators have generally elected not to quantify the positive and negative factors in the evaluation but merely to identify them and indicate their relative significance. This is the procedure followed in this summary. The characteristics of each plan are assessed on a comparative basis in each category. The significance of each category is designated in relationship to the similar characteristics in each of the other eleven plans.

Since there are degrees of difference in the allocation of significance (one plan may combine offsetting good and bad features within the same category), six levels of significance have been designated: Very Positive, Positive, Partially Positive, Neutral, Negative and Very Negative. While the argument might be advanced that an additional degree of negative might be used, the significance lies in the uniformity of rating, whatever the designation. In the plan summaries, positive and negative assessments will be followed by a phrase or sentence to identify the impact of concern, which may then be reviewed further in the plan evaluation. Neutral impacts are not identified since they are judged not to be significantly different from all other plans.

Summary: Plan 1 - Level One, Water Oriented

Very Positive

Resource Demand: Lowest electrical power and modest chemical requirements.

Positive

Regionalization: Regionalized wastewater treatment combined with localized stormwater treatment.

Land Use Changes: Least land use, esthetic potential in local stormwater detention ponds.

Public/Political Perception: Previous planning in NEOWDP has provided an entree. Limited disruption and limited institutional change.

Stormwater Treatment: Trouble free - highly localized

Partially Positive

Design Features: Most localized stormwater treatment.

Reliability: Hazards of conventional process, limited control of viruses, metals, etc.

Flexibility: Conventional process may be converted to land or tertiary add-on. Limited by N.W. Interceptor.

Negative

Ecological Considerations: No recycling, limited improvement.

Residuals: Include air pollutants, chemical sludges.

Special: North West Interceptor will significantly reduce flows in the Rocky River, impacting esthetics and recreation. Flexibility of plan will be affected.

Very Negative

Disposal Methods: 100% incineration of sludges.

Summary: Plan 2, Level One, Land Oriented

Very Positive

Disposal Methods: All residuals are recycled.

Special: Introduction of strip mine reclamation, recovery of agricultural recreational potential.

Positive

Design Features: Application rate related to crops, storage reservoirs for control of return flow; sludge disposal to strip mine area.

Ecological Considerations: Promotes recycling, land rehabilitation, moderate improvement to aquatic conditions, associated land.

Stormwater Managment: Local collection, treatment and discharge. Relatively trouble free treatment. Local reuse potential for non-potable uses.

Residuals: Secondary residuals, both sludges and effluent reuseable.

Partially Positive

Regionalization: Local stormwater treatment reduces effect of high interception and interbasin transfer of wastewater.

Reliability: Known hazards of secondary treatment; limited by single transmission tunnel. Failure limited by dispersed secondary treatment.

Flexibility: Secondary treatment can go in either direction, in-basin land treatment adaptable. Effluent tunnel is a commitment to land.

Negative

Land Use Changes: Major agricultural land requirements, mitigated in part by strip mine reclamation. Water related land improved but major advantages lost in single wastewater treatment enclave.

Public/Political Perceptions: Requirement for major institutional changes to include out-of-basin areas, opposition to single purpose application, transfer of urban problem.

Hydrology: Major flow reductions in middle basins, lower Cuyahoga, relieved by local stormwater treatment. Lower water table, increased flow in north central irrigation area.

Summary: Plan 3, Level Two, Water Oriented

Positive

Regionalization: Plant location includes regionalized stormwater treatment located to maintain stream flow with treated effluent; flow maintenance in Rocky River.

Land Use Changes: Minimal land requirements, water associated land improvement, little disruption.

Partially Positive

Ecological Considerations: Aquatic improvement based on Level Two, but failure to recycle products adds to only a moderate improvement.

Resource Demand: Moderate overall requirement, low energy, high chemical input.

Public/Political Perception: Limited land requirement will not stimulate opposition but revision in regionalization will require basin-wide coordination; cost factors in going to Level Two.

Residuals: Amount of inorganic treatment will produce increased inorganic sludges, however, they are generally recyclable.

Negative

Disposal Methods: Incineration accounts for 60% of disposal leaving limited strip mine and agricultural application.

Special: Stormwater flows to the sanitary treatment system are large enough to require incremental capacity.

Summary: Plan 4, Level Two, Land Oriented

Very Positive

Disposal Methods: All residuals are recycled.

Special: Use of sludges for strip mine rehabilitation, development of agricultural and recreational potential.

Positive

Regionalization: Increased regionalization of stormwater treatment.

Ecological Considerations: Promotes recycling, land rehabilitation, major improvement to aquatic conditions, associated land.

Residuals: Secondary residuals, are completely reusable.

Partially Positive

Flexibility: Secondary treatment and in-basin land treatment adaptable to change; downgraded by effluent tunnel.

Stormwater Management: Treatment to Level Two involves regionalization, less dispersed discharge pattern.

Negative

Public/Political Perceptions: Requirements for major institutional change, opposition to single purpose land area, loss of tax duplicate, cost of Level Two plan, lower flows in river versus improved water quality, esthetics, recreational opportunity.

Very Negative

Land Use Changes: Major requirements for agricultural land mitigated by strip mine reclamation, water related land improvement, major advantages lost in single wastewater treatment enclave; possible aerated lagoon requiring major land-water conversion.

Hydrology: Major flow reduction in middle basins, lower Cuyahoga, most of stormwater transported out-of-basin. Lowered water table and major flow increase in North Central streams.

Summary: Plan 5, Level One, Combination, Water Oriented

Very Positive

Flexibility: At Level One with a minor, in-basin land component, both the investment and physical structure offer high potential for change.

Positive

Resource Demand: Moderate energy demand and minimal chemical requirement.

Land Use Changes: Limited in-basin land treatment requires little dislocation, provides open space, strip mine rehabilitation will assist agriculture, recreation.

Public/Political Perceptions: Institutional changes required, but positive factors tend to balance negative in this plan, avoidance of out-of-basin problems.

Stormwater Management: Local collection, treatment and discharge, relatively trouble free treatment, sedimentation, erosion control, local non-potable reuse potential.

Hydrology: Regional sanitary plants and localized stormwater discharge. Some augmentation from water storage, flood dampening.

Residuals: Some chemical sludges but generally recyclable.

Partially Positive

Regionalization: Regionalization of wastewater and localization of stormwater treatment.

Design Features: Introduction of upper, middle and lower basin design combinations.

Reliability: Hazards of conventional treatment apply, virus control, overflow problems.

Disposal Methods: While incineration is still used, more than 55% of sludges are recycled in strip mine rehabilitation, agricultural disposal.

Summary: Plan 6, Level One, Combination, Land Oriented

Positive

Design Features: Combines in-basin land treatment, middle basin water discharge and shoreline secondary plants transferring with limited hydrologic effect. Primary capacity provided for overflows.

Ecological Considerations: Within the limitations imposed by Level One treatment there is aquatic and land improvement, recycling.

Resource Demands: Low chemical demand and moderate energy required.

Stormwater Treatment: Localized treatment, local discharge, generally trouble free and numerous local options for use of non-potable water.

Partially Positive

Regionalization: Sub-regional configuration for discharge, local stormwater treatment.

Reliability: Will combine deficiencies and values of land/water, hazards of conventional process, overflow control.

Flexibility: As a Level One plan, considerable option is retained until effluent tunnel built.

Hydrology: Flow maintained in lower Cuyahoga basin and creation of only half flow problems in North Central streams.

Residuals: Generally useful but with added chemical sludges in middle basin plants. Concept of crops as residuals for management.

Summary: Plan 7, Level Two, Combination, Water Oriented

Positive

Land Use Changes: Land treatment limited to in-basin requires little dislocation, provides open space. Strip mine reclamation provides agricultural and recreational potential.

Partially Positive

Regionalization: Emphasis on smaller, localized plants in upper basins, additional separate stormwater treatment plants.

Design Factors: Upper basins generally treated as unit potential, reuse of current plant capacity, limited reuse potential.

Ecological Considerations: Reflects Level Two stream improvement, with associated land, recreational potential, otherwise ecological effect is minimal.

Resource Demands: Minimal energy requirements coupled with high chemical requirements results in moderate overall demand.

Public/Political Perceptions: Institutional charges required for basin-wide coordination, Level Two cost factors; but plant reuse, avoidance of out-of-basin problems, provision of open space and flow augmentation gave this moderate appeal.

Hydrology: Despite regionalization of stormwater treatment, greater use of separate stormwater plants and upper basin storage mitigate effects on stream flow.

Residuals: Major use of chemicals will increase inorganic content of sludges, however, they are generally reusable, particularly for acid neutralization.

Summary: Plan 8, Level Two, Combination, Land Oriented

Positive

Design Features: Combines in-basin land treatment, middle basin tertiary treatment with flow maintenance and secondary shoreline plants transmitting treated effluent, no high rate applications.

Ecological Considerations: As a Level Two, land oriented plan, this system presents the best combination plan aspect in ecological encouragement, both aquatic and land, extensive recycling.

Partially Positive

Regionalization: Highest land treatment in combination plan, dispersed stormwater treatment and discharge.

Reliability: Increased options for control, moderate application rates in most areas, with exception of Rocky River, dispersed secondary treatment land failure, single transmission tunnel.

Flexibility: Secondary treatment and high land treatment in-basin affords high change potential, limited when construction of effluent tunnel is begun.

Hydrology: Flow maintenance and augmentation from water storage are provided by extensive land treatment areas and tertiary plants in middle basins, less severe effects on North Central streams than full land plan.

Residuals: Chemical sludges limited, and secondary sludges, wastewater recycled, some reuse from tertiary plants.

Disposal Methods: Major use in strip mine reclamation, some use in agricultural application along with effluent. Downgraded by 35% incineration.

Summary: Plan 9, Level Two, Combination, Land Oriented

Partially Positive

Ecological Considerations: Limited improvement based on Level Two effluent.

Negative

Design Features: Combines worst features of both methods, in-basin primary treatment, aerated lagoons.

Resource Demands: Uses more of everything than other combination plans.

Public/Political Perceptions: In addition to interbasin transfer problems, must be downgraded on raw sewage transmission and greatly reduced stream flow.

Flexibility: Limited after tertiary plants and major pipelines are constructed.

Hydrology: May dry up some small streams.

Disposal Methods: 58% incineration, agricultural disposal questionable.

Very Negative

Regionalization: Consolidation of sewage and stormwater treatment far too great.

Reliability: Poor, based on pipeline failure, corrosion, limited options in plant failure which would be massive.

Land Use Changes: Introduction of aerated lagoons, land conversion to water, shift in land use quality, multiple transmission lines.

Special: Transmission of raw sewage not only consitutes a hazard but eliminates all reuse options in-basin.

Summary: Plan 10, Level Two, Advanced Biological

Very Positive

Disposal Methods: Sludges disposed 95% to strip mine area, 5% agricultural.

Positive

Regionalization: Both sanitary sewage and stormwater treated together, but with some localized return.

Ecological: Based on Level 2, complete recycled sludges.

Land Use Changes: Limited land use requirement, water associated land improvement.

Partially Positive

Resource Demands: Moderate overall requirement, high chemical, low energy.

Public/Political Perceptions: Limited land requirement, Level Two water improvement, also Level Two taxation.

Residuals: Increase in inorganic sludges but generally reusable.

Negative

Design Features: Constraint of single plant design. Questionable efficiency of combined treatment of stormwater. Not suited to industrial discharges.

Special: Stormwater volumes to be treated in combined plants will dictate plant size.

Summary: Plan 11, Level Two, Advanced Physical-Chemical

Positive

Regionalization: Stormwater treated in sanitary plants, effort made to distribute return as widely as possible.

Partially Positive

Land Use Changes: Limited land use requirements, but storage problems for chemicals and land for landfill reduce this below Plan 10.

Negative

Design Features: Constraint of single plant design.

Ecological Considerations: While plan provides Level Two effluent, it uses the most resources and provides the least return.

Residuals: No usable residuals.

Very Negative

Resource Demand: Highest chemical demand by far, moderate energy requirements.

Flexibility: Least flexible of any plan in opportunity for change.

Disposal Methods: All products incinerated to ash in regeneration process.

Special: Stormwater volumes will dictate plant size, no recycling, incineration of all products.

Summary: Plan 12, Level Two, Land Oriented

Positive

Regionalization: Is effective in-basin

Residuals: Secondary treatment, entirely reusable.

Partially Positive

Ecological Considerations: Level Two water improvement, large interconversion of land to water ecology, no land rehabilitation.

Disposal Methods: Agricultural disposal must be downgraded by sludge application related to mini-border technique.

Negative

Design Features: Combination of uncertainties, raw sewage transmission, lagoon design, disposal design.

Very Negative

Reliability: Poor, based on pipeline failure, corrosion, limited options in event of failure, size of aerated lagoon operation, high rate applications.

Land Use Changes: Highest land use in-basin, public ownership required, high land/water interconversion, public access limited.

Public/Political Perceptions: Negative based on high visibility, esthetic defects, multiple use and public access denied, dislocation of population.

Special: Use of aerated lagoon, mini-border technique and other high rate application, single purpose sewage treatment.

As a supplement to the summary pages of the 12 plan evaluation, a display of ecological impacts is attached, indicating in more specific detail, the background used to arrive at the rating for Ecological Considerations in each plan. The criteria in the chart, and the value system applied, are fully explained, beginning on page 230. Essentially, a positive, negative and intermediate rating is applied, compounded by the importance attached to a particular criteria based on an ecological approach alone. There may be some disagreement with the weighting applied in the following chart, since this is a personal and professional value judgement. However, since the bases for the judgement is fully displayed in the explanatory material, it will serve as a useful adjunct to the general summary.

Also supplemental to this summary and providing significant input to the evaluation, are eleven attachments at the end of this report, discussing economic, social, physical and technological concerns that apply in varying degree to each of the plans discussed.

The criteria and value system for this ecological summary are developed, beginning on page 230.

Table **42** AN EVALUATION OF ECOLOGICAL IMPACTS OF WASTEWATER MANAGEMENT ALTERNATIVES FOR THE THREE RIVERS WATERSHED

The following criteria are rated by plan for ecological impact on:

(a) aquatic - within Three Rivers
(b) aquatic - North Central Ohio
(c) land - within Three Rivers
(d) land - within North Central Ohio
(e) land - Southeastern Ohio
(f) Lake Erie

Energetics:	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
1. Which plan consumes the least amount of irreplaceable natural resources such as fuels, chemical coaggulants, electrolytes, and organic compounds?	1 (10)	3 (30)		3 (30)	1 (10)	2 (20)		2 (20)	1 (10)	1 (10)			3 (30)	10
2. Which plan requires the least electrical power annually?	3 (30)	1 (10)	3 (30)		3 (30)	2 (20)	3 (30)	1 (10)		2 (20)	3 (30)		3 (30)	10
3. Which plan contributes most toward achieving a P/R ≈ 1 ratio for impacted ecosystems?	1 (5)	3 (15)	1 (5)	3 (15)	1 (5)	2 (10)	1 (5)	1 (10)	3 (15)	2 (10)	1 (5)	1 (5)	3 (15)	5

Rating criteria for question 1:

Chemical Consumption (#/day x 1000)	Value
0-200	3
200-400	2
400-600	1

Rating criteria for question 2:

Electrical Consumption Megawatt hrs./day	Value
3000-4000	3
4000-5000	2
5000-6000	1

Rating criteria for question 3:

Discharged Phosphate (PO_4) (Tons/yr.)	Value
0-100	3
100-200	2
200-300	1

Table 42 (Cont.)

Question	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
4. Which plan best promotes the development of complex, weblike food chains?	1	3	1	3	1	2	1	2	3	2	1	1	2	1
Rating criteria: Same as question 3--Discharged Phosphate.														
5. Which plan maximizes the return of humic materials to ecosystems of origin?		3 (15		3 (15)	1 (5)	1 (5)	1 (5)	1 (5)	3 (15)	1 (5)	2 (10)	2 (10)	3 (15)	5
Rating criteria: All land — Value 3; Combination without incineration + AWT with sludge disposal — 2; Combination with incineration — 1														
6. Which plan produces effluent that requires the least expenditure of human labor and fossil fuels (energy supplements) to maintain stability in receiving agricultural, aquatic, and terrestrial ecosystems? Or which plan supports the largest biomass per unit of energy flow?	3 (30)	1 (10)	3 (30)	1 (10)	2 (20)	1 (10)	2 (20)	1 (10)	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	10
Rating criteria: AWT — Value 3; Combination with land treatment in basin — 2; ALT + combinations with land treatment in West — 1														
Community Structure:														
7. Which plan maximizes for diversity of aquatic life within the limits imposed by natural substrates?	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	1 (10)	3 (30)	3 (30)	3 (30)	3 (30)	3 (30)	3 (30)	3 (30)	10
Rating criteria: Level II + Level II stormwater treatment — Value 3; Level II + secondary treatment of stormwater — 2; Level I + Level I stormwater treatment — 1														

Table 42 (Cont.)

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
8. Which plan best contributes to the development of stratification and highly organized communities of plants and animals?	1	1	3	3	1	1	3	3	3	3	3	3	3	1
Rating criteria: Same as question 7														
9. Which plan best encourages species with narrow range of tolerance to environmental factors?	1	1	3	3	1	1	3	3	3	3	3	3	3	1
Rating criteria: Same as question 7														
10. Which plan maximizes biotic storage of major plan nutrients?	1	3	1	3	1	2	1	2	3	2	1	1	3	1

Rating criteria: Discharged PO_4 (Tons/yr)

	Value
0-100	3
100-200	2
200-300	1

Nutrient Cycling:

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
11. Which plan maximizes recycling of phosphorus and nitrogen?	1 (10)	3 (30)	1 (10)	3 (30)	1 (10)	2 (20)	1 (10)	2 (20)	3 (30)	2 (20)	1 (10)	1 (10)	3 (30)	10
Rating criteria: Same as question 10.														
12. Which plan maximizes for biological control of nutrient cycles?	1	3	1	3	1	2	1	2	3	2	1	1	3	1

Rating criteria: PO_4 (Tons/yr.)

	Value
0-100	3
100-200	2
200-300	1

Table 42 (Cont.)

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
13. Which plan maximizes reuse of organic sludges as soil conditioners? Rating criteria: (Value) All land — 3 Combination w/o incineration + AWT with sludge — 2 Combination with incineration — 1		3 (15)		3 (15)	1 (5)	1 (5)	1 (5)	1 (5)	3 (15)	1 (5)	2 (10)	2 (10)	3 (15)	5
14. Which plan generates least inorganic sludges or sludges with very poor reuse potential? Rating criteria: Chemicals (#/day x 1000) (Value) 0-200 — 3 200-400 — 2 400-600 — 1	1 (5)			3 (15)	1 (5)	2 (10)		2 (10)	1 (5)	1 (5)			3 (15)	5
15. Which plan least disturbs natural hydrologic regimes? Rating criteria: (Value) AWT — 3 Combination in basin land treatment — 2 ALT + combination with land treatment in West. — 1	3 (30)	1 (10)	3 (30)	1 (10)	2 (20)	1 (10)	2 (20)	1 (10)	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	10
16. Which plan least threatens the quality of ground water supplies? Rating criteria: Same as question 15.	3 (15)	1 (5)	3 (15)	1 (5)	2 (10)	1 (5)	2 (10)	1 (5)	1 (5)	1 (5)	3 (15)	3 (15)	1 (5)	5
17. Which plan best retards leaching of plant nutrients into ground water? Rating criteria: Same as question 15.	3 (15)	1 (5)	3 (15)	1 (5)	2 (10)	1 (5)	2 (10)	1 (5)	1 (5)	1 (5)	3 (15)	3 (15)	1 (5)	5

Table 42 (Cont.)

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
<u>Life History</u>: (Aquatic Ecosystems Only)														
18. Which plan contributes most to the development of a great variety of ecological niches?	1	1	3	3	1	1	1	3	3	3	3	3	3	1
Rating criteria: Same as question 7.														
19. Which plan best encourages populations of large organisms?	1	1	3	3	1	1	3	3	3	3	3	3	3	1
Rating criteria: Same as question 7.														
20. Which plan best encourages species with long, complex life cycles?	1	1	3	3	1	1	3	3	3	3	3	3	3	1
Rating criteria: Same as question 7.														
<u>Selection Pressure</u>: (Aquatic Ecosystems only)														
21. Which plan is most compatible with a "feedback control" type populations growth forms?	3	1	3	1	2	1	2	1	1	1	3	3	1	1
Rating criteria: Same as question 7.														
22. Which plan best enhances control of nuisance organisms such as mosquitoes, house flies, midges, leeches, sludgeworms, aquatic weeds, and bluegreen algae?	3 (15)	1 (5)	3 (15)	1 (5)	2 (10)	1 (5)	2 (10)	1 (5)	1 (5)	1 (5)	3 (15)	3 (15)	1 (5)	5

Rating criteria:

	Value
AWT	3
Combination with land treatment in basin	2
ALT + combinations with land treatment in West	1

Table 4[illegible] (Cont.)

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
23. Which plan best promotes control of pathogenic organisms.including certain bacteria, viruses, and "swimmers itch"?	1 (5)	1 (5)	1 (5)	3 (15)	2 (10)	3 (15)	2 (10)	3 (15)	3 (15)	3 (15)	3 (15)	1 (5)	3 (15)	5

Rating criteria:

	Value
ALT + combinations with land treatment in West	3
Combination with land treatment in basin	2
AWT	1

Overall Homeostasis:

	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
24. Which plan maximizes mutualistic or synergistic relationships among living organisms?	1 (5)	1 (5)	1 (5)	3 (15)	2 (10)	3 (15)	2 (10)	3 (15)	3 (15)	3 (15)	1 (5)	1 (5)	3 (15)	5
Rating criteria: Same as question 7.														
25. Which plan interferes least with the natural successional development of ecosystems?	1 (5)	1 (5)	1 (5)	3 (15)	2 (10)	3 (15)	2 (10)	3 (15)	3 (15)	3 (15)	1 (5)	1 (5)	3 (15)	5
Rating criteria: Same as question 7.														
26. Which plan best promotes the rehabilitation of destroyed or badly distrubed terrestrial ecosystems (stripmined lands, for example)?		3 (30)	3 (30)						3 (30)					10

Rating criteria: Sludge to strip areas — Value 3

27. Which plan in case of mechanical failure provides maximum protection for ecosystems?

28. Which plan generated the least quantity of potentially harmful biological and chemical aerosols?

Not able to judge.

Table 42(Cont.)

Question	1	2	3	4	5	6	7	8	9	9A	10	11	12	Importance Value
29. Which plan requires least disturbances or destruction of terrestrial ecosystems (land use) for pipelines, sewers, and structural facilities? Rating criteria: Land Required (1000 acres) — Value 0-50 — 3 50-100 — 2 100-+ — 1	3 (30)	1 (10)	3 (30)	1 (10)	3 (30)	2 (20)	3 (30)	1 (10)	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	10
30. Which plan requires the least conversion of terrestrial ecosystems into aquatic systems? Rating criteria: — Value AWT — 3 Combination — 2 All Land Treatment — 1	3 (30)	1 (10)	3 (30)	1 (10)	2 (20)	2 (20)	2 (20)	2 (20)	1 (10)	1 (10)	3 (30)	3 (30)	1 (10)	10
31. Which plan best protects plant, animal and human life from possible cumulative toxic effects of heavy metals or other harmful industrial and agricultural chemicals? Rating criteria: — Value Water based plans — 3 Combination plans — 2 Land based plans without secondary sludge — 1	1 (10)	1 (10)	3 (30)	1 (10)	2 (20)	2 (20)	2 (20)	2 (20)			3 (30)	3 (30)		10

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VIII. EVALUATION OF PHASED AND COSTED SYSTEMS (THREE PLANS)

A. INTRODUCTION

The concept of a multiple means approach in the planning of multipurpose projects has been acknowledged for a number of years. A 1966 publication of the National Academy of Sciences entitled Alternatives on Water Management summarized the concept in these words:

> "A review of current efforts to manage water to serve the needs and desires of man reveals that all aspects of water management would be improved by planning that would maintain flexibility for the future, foreclose as few choices as practicable, and put fresh demands on science to predict consequences and to provide alternatives to meet changing needs. Specifically, such an emphasis would call for applying more intensively present knowledge of the behavior of water, land, and man in two ways: first, by identifying all available alternatives for coping with water problems and taking systematic steps to discover new alternatives; and second, by improving methods of recognizing the social as well as the physical consequences of water management and of weighing alternatives."

Where efforts to curb water pollution are cited, alternatives are indicated in goal establishment, engineering measures, other management measures, new institutional arrangements, timing, size and locations. The idea that the same goal may be sought by both management and engineering means is basic, and the exploration of management alternatives in water resource management should have attained the status of a standard procedure.

In many water resource development efforts, a commitment to traditional single means has often obscured the consideration of multiple means potential. In the case of water supply, the characteristic response has been to seek more water rather than to

reduce consumption or provide for reuse. Irrigation projects were designed to provide more food, among other purposes, with no consideration of food demand or of alternative means of enhancing food production, such as supplemental irrigation in water surplus areas, drainage or improved seeds. Similarly, waste disposal has followed the traditional approach of examining ways of diluting the waste in a natural stream, with relatively little attention to ways of reducing the waste itself before it reached the stream, or to means of improving stream quality other than by dilution.

One of the most consistent features of water resources planning in the United States has been the projection of demand based on historical use, population and land use projections, and potential industrial growth. The pitfalls of demographic projection, with reference to this project, are explored in Attachment C - Analysis of Wastewater Projections. The significance of this analysis relates not only to system sizing and a variety of related impacts, but also the concern that other management alternatives have not been explored to a significant degree. Mention has been made of non-structural devices designed to reduce stormwater pollution; flow equalization has been included to limit necessary plant size; but specific consideration is lacking for measures which may reduce the wastewater loads. What, for instance, is the potential for relining sewers to reduce or eliminate infiltration that now constitutes such a sizeable percentage of the treatment load. What is the potential for curbing leakage and water waste in both industrial and domestic usage. What opportunities exist in pricing and technology for reducing consumption and promoting reuse? The examination of the range of ways in which water use (and wastewater volumes) might be changed while population

and manufacturing actively increase, might be productive of more conservation than in water alone.

The basic weakness of water use and wasteload forecasting is not that it incorporates a series of uncertainties to form a tenuous foundation for major development, but that it fosters an approach to management that draws attention away from other variables in the situation. Since, however, the projection is common to all plans, this sensitivity will not interfere with the evaluation of the three final plans.

The evaluation of the remaining alternatives follows the pattern used to evaluate the twelve alternatives. Reference is made to items of general consideration examined in that section. The eleven evaluation categories, condensed from the range of parameters considered under Methodology, are re-examined in detail appropriate to the final nature of the three plans. In addition, each plan is considered in relation to their projected contribution to both regional and national objectives and their component aspects of environmental quality, social well being and economic improvement.

As with the preceding evaluations, the potential effects of the proposed technology and development are indicated, based on the conditions of the area, and tempered by appropriate concern for the uncertainties on any project with an extended time horizon. The various preferences, based on the evaluations, are related in the concluding section.

B. Evaluation Categories

Reference is made to descriptions of major evaluation categories prepared for analysis of the range of alternatives and appearing on pages 285 through 293. For convenience a brief review of category content is presented here.

1. Ecological Considerations

The impacts of Plan A Levels One and Two, and Plans B and C are discussed in terms of the effects on ecosystem energetics, structural components of biological communities in the several ecosystems, nutrient cycling, life histories of component organisms, selection pressure against potential species and overall homeostatic control mechanisms for the major ecosystem affected by each of the wastewater management plans. These categories are defined in the section on Parameter Development beginning on page 28 and discussed under Ecological Analysis beginning on page 429.

2. Resource Demands

This section considers the consumption of power, fuel and chemical resources in the several treatment processes, the secondary environmental effects in their production and use, the conservation or loss of the resource characteristics of wastewater and the interrelationship of these factors to the larger environment as previously outlined.

3. Reliability

Reliability factors include the effectiveness of the various system components from collection to disposal, stress points or other inadequacies, their susceptibility to failure for any reason,

and the potential for creation of nuisances or hazards in case of accident.

4. Land Use Changes

This section comprehends the requirements for land in the development, construction and operation of the treatment system, the related potential for open space, recreational or agricultural benefits and the negative consequences of conversion to water uses, esthetic degradations, or prevention of access.

5. Public/Political Perceptions

This section includes both social and institutional factors expressed in the way that people view the effect of the development or change required by a particular plan or system, and assesses the probable reaction to innovation and philosophical change.

6. Economic Considerations

The economic aspects of the three plans are reviewed in the Economic Analysis of Plans beginning on page 413.

7. Flexibility

This section addresses the ability of the final plans to be adaptable to change in either phasing or structure, to respond without major penalties to change induced by policy, price or technology.

8. Stormwater Management

This section indicates the effects that derive from the methods of control, collection and treatment of stormwater.

9. Hydrologic Effects

The effects of a treatment and disposal plans on stream flow, erosion, sedimentation and aquatic habitats are discussed in this section.

10. Residuals

This section discusses the characteristics and utility of the pollutants removed from wastewater and retained for disposal with particular reference to the variation imposed by the treatment scheme.

11. Disposal Methods

Since wastewater treatment cannot repeal the law of conservation of matter, the process results in a residual which must be disposed of in some section of the environment. The costs and requirements of the several plans are discussed.

C. Contributions to Regional Objectives

The Water Resources Planning Act of 1965 directed the Water Resources Council to establish principles and standards to guide Federal participation in planning the use of the nation's water and related land resources and for evaluating water resources projects and programs. The proposals have been under study since late 1968 and have not yet been finally established, but the general thrust has been toward a multi-objective approach to water and land resources planning. Planning would be directed to improvement in the quality of life through contributions to National Economic Development, Regional Development, Environmental Quality and Social Well Being.

Testimony on the proposals generally indicated that the multi-objective approach was highly favored in natural resources planning. The newer objectives are able to relate far more readily to the changing objectives of society and give room for expression of emergent concern, particularly for the functioning ecosystems of the resource base which constitute the life support systems for all living matter.

This section and the one that follows, express the concern for these larger objectives. In this report social, economic and environmental considerations are viewed within the context of regional objectives. For purposes of example, selected indicators are listed by category, without implying that any plan is responsive in these regards.

1. Environmental Quality

   Acres of greenbelt developed or preserved

   Miles of natural stream preserved

   Improvement of water quality

   Restoration of fish or wildlife habitat

   Prevention of erosion

   Conservation or improvement of scenery

2. Social Well Being

   Flood protection - security of life

   Water quality protection - health maintenance

   Provision of recreational opportunity

   Dislocation caused by development

   Improvement of community stability

   Opportunity for new employment

3. <u>Economic Objectives</u>

Improved regional economic base

Prevention of flood control loss

Maximizing regional employment and income

Irrigation benefit to agriculture

Enhanced property value on water

Improved income distribution within the region

Each of the indicators obviously may have positive or negative aspects depending on the characteristics of the alternative.

D. <u>Contributions to National Objectives</u>

The national objectives account is interrelated to regional objectives since the enhancement of the region will also enhance the nation unless it is at the expense of other regions. For instance, within the scene of selective national food shortages, the regional benefits derived from irrigation extend the national food supply. Other national benefits might include:

Water quality improvement related to increased productivity

Water supply benefits for development

Use of unemployed resources

Pollution control benefit to downstream regions

Increased employment due to resource management

Essentially this account could include any increase in national income, resulting from management of water resources to achieve a range of domestic, municipal, industrial and agricultural purposes. Its values range from land stabilization and watershed protection through navigation, power production, and flood control purposes to enhancement of broad recreational opportunities.

E. General Considerations

While a categorical evaluation is used for each plan, certain aspects were more appropriately analyzed as a unit. The following sections are the economic analysis and the ecological analysis of the final plans.

In addition to these specific plan references, the attachments to this report provide a signficant input to plan evaluation. Economic concerns are addressed in Attachment D - The Impact of Federal Financing, Attachment E - Fiscal Capacity of the Region, Attachment F - Impact of Land Treatment on Tax Revenues, and Attachment G - Energy and Chemical Requirements.

Socio-economic aspects are considered in Attachment I - Distributive Equity, institutional flexibility in Attachment H - Political Acceptance of Innovation, Regional Characteristics for out-of-basin areas are detailed in Attachments A and B. Various technological aspects and uncertainties in wastewater management are examined in Attachment J - Aerated Lagoons, as well as Attachments B and G.

Finally, the adequacy of the planning base is examined in Attachment C - Analysis of Wastewater Projections, and Attachment K - An Out-of-Basin Alternative, not previously considered in this report.

1. Economic Analysis of Plans

(a) Financial Considerations Relating to Plans A, B, and C

When viewed in light of the uncertainties involved in projecting wasteloads and costs over a 50 year period, the total cost differences exhibited by plans A, B and C in table 43 are quite small. The most expensive alternative, plan A, exceeds the cost of the least expensive alternative, plan C by 7 to 11 percent depending upon the discount rate used to arrive at present worth. Differentials of this magnitude are simply not large enough to provide a firm basis for a choice among alternatives. Furthermore, it appears that by discounting costs to 1972, very valuable flexibility inherent in plan C is being ignored.

The Formulation Final Report indicates that "until 1985, plan C is primarily a water based plan, with a land treatment system added later." (P. IV-10) The cost figures presented in table V-12 indicate that construction of the specialized capital for the land treatment system is scheduled for around 1980. Thus, the ultimate decision relating to the type of treatment system to be used will not have to be made for approximately 7 years. These 7 years can be very profitably used to answer a number of questions relating to land treatment technology and to generate the public support necessary for the actual implementation of a land treatment system. In addition, future changes in prices, eg, chemicals and power and technological advances in water based treatment methods can then be incorporated into the final decision making process.

Thus, the decision to leave the treatment system option open for another 7 years seems to be a wise one. But having done this, there is no justification for comparing plans on the basis of present worth discounted to the year 1972. Costs should be discounted to the

TABLE 43

A. Total Present Worth of Plans A, B and C (,000)

Treatment Category	Plan A	Plan B	Plan C
Municipal-Industrial[1]	1,736,700	1,644,000	1,767,200
5-3.8% Stormwater[2]	1,252,000	1,198,900	924,000
Total	2,988,700	2,843,900	2,691,200
Municipal-Industrial	1,393,900	1,321,000	1,474,300
7% Stormwater	1,059,800	1,019,400	776,200
Total	2,453,700	2,340,400	2,250,500
Municipal-Industrial	1,001,100	949,700	1,105,400
10% Stormwater	814,800	789,500	586,400
Total	1,815,900	1,739,200	1,691,800

B. Percent Advantage in Total Present Worth

	A over C	B over C
Municipal-Industrial (5-3/8%)	1.8%	7.5%
Municipal-Industrial (7%)	5.8%	11.6%
Municipal-Industrial (10%)	10.4%	16.4%
	C over A	
Stormwater (5-3/8%)	35.5%	
Stormwater (7%)	36.5%	
Stormwater (10%)	38.9%	
	C over A	
Total (5-3/8%)	11.1%	
Total (7%)	9.0%	
Total (10%)	7.3%	

SOURCE:

Based upon data from Wright-McLaughlin Engineers U.S. Army Corps of Engineers Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study Formulation Final Report March, 1973, Table V-2.

[1]Includes land and contingencies.

point in time when an unrevocable decision relating to the type of treatment system must be made. Judging from the detailed cost figures, in the present case this should be somewhere around 1980.[1]

It is impossible to determine the precise impact that discounting to the year 1980 would have on the cost differentials presented in table 43. It is possible, however, to predict the direction of change. The heavy capital costs associated with the land treatment system are scheduled to begin around 1980. The impact of these costs is reduced significantly when they are discounted back to 1972. This is, of course, also true of the 1980 capital costs incurred under the water based treatment system. The 1980 water based capital costs ($428,935,000) are, however, much smaller than the 1980 land system capital costs ($913,697,000). Discounting to 1980 should therefore lower the cost of plan A relative to the cost of plan C.[2] In terms of total costs, the present worth of plans C and A would move closer together. When municipal-industrial waste is considered separately, the discounting to 1980 would increase the cost advantage of plan A and plan B over plan C. Plan B might therefore exhibit a cost advantage in the treatment of municipal and industrial wastes alone which would be large enough to have a significant bearing upon the choice among alternatives.

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[1]The period from the present to 1980 should, perhaps, be subject to closer scrutiny to determine the probable cost of postponing the ultimate decision on the type of treatment system to the year 1980. It would be helpful to know the cost of converting from plan C to plan A in 1980 and vice-versa. It is also possible that a fourth alternative covering the period from 1973 to 1980 could reduce the expected conversion costs.

[2]An offsetting change which appears much smaller in magnitude would occur in relation to the lower O and M costs associated with land treatment in the years following 1985.

The table 43 figures further illustrate that the major advantage of the land treatment system lies in its ability to handle stormwater economically. Stormwater treatment costs are quite high, accounting for between 30 and 40 percent of the total public entity costs. The relative importance of stormwater costs would be reduced considerably by the addition of industrial pretreatment costs. The industrial costs have been omitted from table 43 since they were identical for all three plans.

Tables 44 and 45 present annual cost data for municipal-industrial and stormwater separately and for both combined. In all 3 cases the low cost plan for the given wastewater component was used.[3] The use of 3 different interest rates illustrates the tremendous impact that financing charges have on a project entailing the use of long-lived capital equipment. The 7 percent rate will be used in all discussions since it is closest to the rate at which the public entity could borrow in today's financial market.

The entire system will be operational by 1990. At this time the total annual costs will level off at about $220-$225 million. Since population will continue to grow, the per capita costs will fall steadily from $58 in 1990 to $46 in 2020. This is a natural result of building the system to accomodate future population growth.. Most of the capital in place by 1990 will be designed to handle 2020 waste loads. The per capita costs will in actuality prove quite sensitive to the accuracy of the population projections used to design

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[3]The stormwater costs do not, therefore, accurately represent the extra costs involved in the treatment of stormwater. To obtain the actual marginal costs associated with the treatment of stormwater, the municipal industrial costs for plan B should be subtracted from the total costs for plan C. This assumes that if municipal-industrial is treated alone, plan B will be used and if stormwater is also treated, plan C will be used

TABLE 44

A. Annual Total Costs for Plans B and C (,000)

Year	Municipal-Industrial Plan B			Stormwater Plan C			Total Plan C		
	5-3/8%	7%	10%	5-3/8%	7%	10%	5-3/8%	7%	10%
1972	30,925	30,925	30,925				30,823	30,823	30,823
1975	50,770	53,994	60,655	15,376	18,163	23,940	64,405	70,382	82,762
1980	58,862	62,901	71,248	29,540	34,713	45,426	90,868	100,959	121,851
1985	83,881	91,166	106,170	54,386	63,994	83,887	161,251	185,421	235,380
1990	101,283	110,555	129,642	69,610	81,898	107,344	191,783	220,392	279,531
1995	103,687	113,090	132,447	70,368	82,693	108,213	195,401	224,288	284,002
2000	122,425	135,243	161,689	77,518	91,231	119,624	193,295	224,009	287,517
2005	125,454	138,291	164,774	77,789	91,505	119,903	195,868	226,689	290,418
2010	128,351	141,161	167,585	78,416	92,181	120,682	190,266	219,493	279,906
2015	131,051	143,889	170,370	78,175	91,737	119,827	191,374	220,339	280,214
2020	133,406	146,190	172,562	79,196	92,943	121,406	193,930	223,068	283,291

B. Annual Per Capita Costs for Plans B and C

Year	Municipal-Industrial Plan B			Stormwater Plan C			Total Plan C		
	5-3/8%	7%	10%	5-3/8%	7%	10%	5-3/8%	7%	10%
1972[1]	$11.26	$11.26	$11.26				$11.22	$11.22	$11.22
1975	17.26	18.36	20.62	$ 5.23	$ 6.17	$ 8.14	21.89	23.93	28.13
1980	18.77	20.06	22.72	9.42	11.07	14.48	28.97	32.19	38.85
1985	24.13	26.22	30.54	15.64	18.41	24.13	46.38	53.34	67.71
1990	26.54	28.97	33.97	18.24	21.46	28.13	50.25	57.75	73.25
1995	25.48	27.79	32.54	17.29	20.32	26.59	48.01	55.11	69.78
2000	28.32	31.28	37.40	17.93	21.10	27.67	44.71	51.82	66.51
2005	27.82	30.67	36.54	17.25	20.29	26.59	43.44	50.28	64.41
2010	27.34	30.07	35.70	16.70	19.63	25.71	40.53	46.75	59.62
2015	27.46	30.15	35.69	16.38	19.22	25.11	40.10	46.16	58.71
2020	27.50	30.14	35.57	16.33	19.16	25.03	39.98	45.98	58.40

SOURCE:

Figures were taken from Wright-McLaughlin Engineers U.S. Army Corps of Engineers Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study Formulation Final Report March, 1973, tables V-8 and V-9.

Part B was based upon part A and the following population projections for the Three Rivers Watershed area: 1970 - 2,746,845; 1975 - 2,941,607; 1980 - 3,136,370; 1985 - 3,476,360; 1990 - 3,816,350; 1995 - 4,069,735; 2000 - 4,323,120; 2005 - 4,508,960; 2010 - 4,694,800; 2015 - 4,772,950; 2020 - 4,851,100. The population projections were taken from Havens and Emerson, Ltd. Consulting Engineers Survey Scope Study for Wastewater Management Program Contract Phase Report Phase I - Part A Municipal Wastewater, May, 1972, table A-1-2.

[1] The 1970 population figure was used to derive the 1972 per capita amounts.

TABLE 45

A. Annual Regional Costs for Plans B and C (,000)

Year	Municipal-Industrial Plan B			Stormwater Plan C			Total Plan C		
	5-3/8%	7%	10%	5-3/8%	7%	10%	5-3/8%	7%	10%
1972	30,925	30,925	30,925				30,823	30,823	30,823
1975	38,967	39,773	41,439	6,585	7,282	8,726	43,991	45,485	48,580
1980	44,305	45,315	47,402	12,591	13,884	16,562	56,650	59,173	64,396
1985	56,420	58,242	61,993	23,519	25,921	30,894	80,696	86,739	99,229
1990	66,769	69,087	73,859	29,318	32,390	38,751	95,363	102,515	117,300
1995	68,711	71,061	75,900	29,947	33,028	39,408	98,264	105,486	120,414
2000	74,848	78,052	84,664	32,519	35,947	43,045	90,261	97,939	113,816
2005	77,817	81,026	87,647	32,781	36,210	43,309	92,491	100,196	116,128
2010	80,818	84,021	90,627	33,231	36,673	43,798	92,827	100,134	115,237
2015	83,421	86,630	93,250	33,469	36,859	43,882	94,665	101,906	116,875
2020	85,947	89,143	95,736	34,085	37,517	44,633	96,852	104,137	119,192

B. Annual Per Capita Regional Costs for Plans B and C

Year	Municipal-Industrial Plan B			Stormwater Plan C			Total Plan C		
	5-3/8%	7%	10%	5-3/8%	7%	10%	5-3/8%	7%	10%
1972[1]	$11.26	$11.26	$11.26				$11.22	$11.22	$11.22
1975	13.25	13.52	14.09	$2.24	$2.48	$2.97	14.95	15.46	16.52
1980	14.13	14.45	15.11	4.01	4.43	5.28	18.06	18.87	20.53
1985	16.23	16.75	17.83	6.77	7.46	8.89	23.21	24.95	28.54
1990	17.50	18.10	19.35	7.68	8.49	10.15	24.99	26.86	30.74
1995	16.88	17.46	18.65	7.36	8.12	9.68	24.15	25.92	29.59
2000	17.31	18.05	19.58	7.52	8.52	9.96	20.88	22.65	26.33
2005	17.26	17.97	19.44	7.27	8.03	9.61	20.51	22.22	25.75
2010	17.21	17.90	19.30	7.08	7.81	9.33	19.77	21.33	24.55
2015	17.48	18.15	19.54	7.01	7.72	9.19	19.83	21.35	24.49
2020	17.72	18.38	19.73	7.03	7.73	9.20	19.96	21.47	24.57

SOURCE:

Part A figures were derived from Wright-McLaughlin Engineers U.S. Army Corps of Engineers Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study Formulation Final Report March, 1973, tables V-8 and V-9. It was assumed that 75 percent of all capital costs would be defrayed by the Federal government.

Part B was based upon Part A and the population figures given in the source note to table 44.

[1] The 1970 population figure was used to derive the 1972 per capita amounts.

the treatment systems. If population grows much slower than expected then the per capita costs will be higher than anticipated since the fixed capital charges will be distributed over a smaller population base.

Speculation relating to the accuracy of population projections is very difficult. The projections underlying the table 44 and 45 figures have recently been revised downward. There is, however, no assurance that the new projections will remain valid for any extended period of time. The difficulties involved in projecting population and wasteloads led the Water Resources Council to make the following statement:

> "Potential errors in the planning process growing out of errors in the projections cannot be eliminated, but their effect can be reduced through the use of sensitivity analysis, by the maintenance of flexibility in the development plan in order to accommodate revised projections at future dates, and by the updating of the projections at periodic intervals."[4]

This suggestion appears quite reasonable but it has not been followed in the formulation of the alternatives for the Three Rivers Watershed area. We do not know what costs would be incurred if the various plans had to be altered to conform to revised population and wasteload projections. If the costs involved in adjusting to changed circumstances are identical for all alternatives, then a sensitivity analysis would be unnecessary and unproductive. This appears highly unlikely, and thus the information generated by a sensitivity analysis

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[4]U.S. Water Resources Council, 1972 OBERS Projections Economic Economic Activity in the United States by Economic Area, Water Resources Region and Subarea, and State, Historical and Projected - 1929 - 2020 Volume 1, p. 6.

would seem to be a crucial input into the decision making process.

The table 44B figures show an annual per capita cost of approximately $50 once the system is fully operational. This is certainly a considerable cost, but it is far below the $100 figure generated by preliminary cost data. Adding the industrial pretreatment costs would raise the total annual per capita cost to about $65. Municipal industrial treatment accounts for about 60 percent of the public entity per capita costs with stormwater treatment adding the remaining 40 percent.[5] The extra cost involved in treating the stormwater is quite substantial.

The regional figures presented in table 45 are, of course, much lower than their national counterparts. The region would be obligated to pay less than one-half of the total cost if plan C were used.[6] If plan B were selected to treat municipal-industrial wastes only, the regional share of total costs would be about 60 percent. Once again, the discrepancy is caused by the high capital requirements for the stormwater treatment system. Because the Federal government pays 75 percent of all capital costs, the treatment of stormwater appears deceptively inexpensive from a regional point of view. Nevertheless the increase in cost associated with the treatment of stormwater remains, in a relative sense quite significant. The stormwater cost increment is nearly 50 percent of the cost of treating municipal and industrial waste alone.

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[5]Stormwater treatment accounted for less than one-third of the present worth of the public entity costs. The difference results from the high ratio of capital to O and M costs for the stormwater treatment system.

[6]Regional costs for the non-industrial sector would actually be somewhat less than the table 45 figures would indicate. The regional authority would be allowed to retain a significant portion of the user fees placed upon local industries.

It is very difficult to estimate the total regional costs because of the uncertain incidence of the industrial pretreatment costs. It appears that a maximum level for regional costs would be about $40 per person per year. A most reasonable estimate might be in the neighborhood of $30 per person per year.[7]

Table 46A presents the federal share of the treatment costs incurred in the Three Rivers area. These figures are not very informative since they give no indication of the probable level of federal expenditures on wastewater treatment for the entire U.S. The table 46B figures were derived by assuming that per capita wastewater treatment costs for the entire U.S. would be equal to the per capita costs in the Three Rivers area for the designated plans. In other words, it was assumed that the entire nation would institute wastewater treatment systems equivalent in both cost and the timing of construction to the systems being considered for the Three Rivers area.

The federal costs for the treatment of both municipal-industrial and stormwater are obviously quite large for the 20 year period between 1975 and 1955. Annual costs approach $6 billion during this period with the 20 year total exceeding $115 billion. Maximum annual

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[7]These figures assume that only the Three Rivers Watershed area will meet the new higher water quality standards. If similar standards are met throughout the country, the only distinction between regional and total costs relates to the payment impact point. A portion of total costs will be paid to the regional authority, another portion will be paid through federal taxes and a final portion will be paid through higher prices placed on goods produced in all parts of the country. Thus, in a most relevant sense, per capita regional and total costs may be considered equivalent when national standards are enforced.

TABLE 46

A. Annual Federal Share of Three Rivers Wastewater Treatment Costs (,000)

Year	Municipal-Industrial Plan B	Total Costs Plan C
1972		515
1975	39,687	80,598
1980	9,892	137,055
1985	38,005	48,685
1990	19,398	50,679
1995	1,496	3,486
2000	43,874	24,278
2005	567	1,324
2010	38,590	14,924
2015	4,338	11,338
2020	23,373	32,325

B. Annual Federal Wastewater Treatment Costs for the Entire U.S. (,000)

Year	Municipal-Industrial Plan B	Total Costs Plan C
1972		39,150
1975	2,912,232	5,914,281
1980	728,546	10,094,101
1985	2,719,258	3,483,412
1990	1,353,398	3,535,874
1995	103,942	242,207
2000	3,048,804	1,687,078
2005	40,370	94,269
2010	2,828,261	1,093,780
2015	334,460	874,160
2020	1,888,772	2,612,183
Aug. '75 - '95	1,928,358	5,756,917
Aug. '75 - '20	1,595,804	2,963,134
Total '75 - '95	38,567,160	115,138,340

SOURCE:

Part A figures were derived from Wright-McLaughlin Engineers U.S. Army Corps of Engineers Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study Formulation Final Report March, 1973, tables V-8 and V-9. It was assumed that 75 percent of all capital costs would be defrayed by the Federal government.

Part B was derived from Part A, the regional population projections from the source note to table 2 and the following national population projections: 1972 - 208,837,000; 1975 - 215,872,000; 1980 - 230,955,000; 1985 - 248,711,000; 1990 - 266,238,000; 1995 - 282,766,000; 2000 - 300,406,000; 2005 - 321,025,000; 2010 - 344,094,000; 2015 - 367,977,000; 2020 - 392,030,000. The U.S. projections were taken from U.S. Bureau of the Census Current Population Reports Series P-25, No. 493 Projections of the Population of the United States by Age and Sex: 1972 to 2020" U.S. Government Printing Office, Washington, D.C. 1972, Table A.

expenditures of $10 billion would be reached in the early 1980's.[8] The annual federal expenditures might be reduced considerably during this early period if the new systems did not have to be constructed immediately in all parts of the country. If construction in some areas was postponed, the federal expenditures during the latter portion of the 50 year period would be increased accordingly. By spreading out the construction of the new systems over time it might be possible to even out annual federal expenditures at about $3 billion throughout the period.[9]

The federal costs involved in the treatment of municipal industrial wastes alone are, of course, significantly smaller. In addition, these costs would be spread more evenly over the 50 year period even if no attempt was made to stagger the construction timing for the treatment systems in different parts of the country. From 1975-1995 the annual federal share of municipal-industrial costs would be about $2 billion whereas the average annual cost for the entire period from 1975-2020 exceeds $1-1/2 billion. Total federal expenditures from 1975 to 1995 would be less than $40 billion.

It is difficult to move beyond the simple presentation of these cost figures. It is meaningless, for instance, to argue that the nation can or cannot "afford" expenditures of this magnitude. Waste-

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[8]It should be noted that these figures all relate to 1972 prices, ie., no inflation has been built into the estimates. Rising costs would undoubtedly cause the actual federal costs to far exceed the figures given in table 46.

[9]The total cost for the nation, ie., federal, local and industrial combined would be quite high for the near future if all portions of the country were required to achieve the new higher water quality standards as soon as possible. These total costs would easily run as high as $15 billion per year during the 1980's.

. . .

water treatment must compete with many other high priority areas for its share of the public dollar. The question is not, therefore, do we have the resources to undertake programs of this magnitude. Instead, we must ask if we wish to devote this quantity of our resources to the solution of this particular problem. Ultimately this question is one which will have to be answered by the general public.

It is, however, safe to conclude that the expenditures involved are large enough to warrant careful scrutiny on the part of the public. That is to say, automatic approval of this magnitude of expenditures is unlikely to be forthcoming. It is therefore imperative to clarify in some detail the benefits to be derived from the various levels of wastewater treatment. It seems reasonable to ask if the benefits of treating stormwater to Level Two standards justify an increase in cost of almost 100 percent. It would also seem reasonable to consider very carefully the wisdom of postponing the compliance date for the new standards in some parts of the country. If this is not done the costs incurred in the near future may be high enough to reduce significantly the prospects for continued public approval of this program.

a. Summary

On the basis of the cost figures for the final 3 alternatives the following general comments seem to be in order:

1. The cost differences as presented at this time are not large enough to provide much guidance in relation to the choice among alternative systems.
2. The flexibility allowed by postponing the institution of the land treatment system until 1980 should prove very

beneficial. The intervening 7 years should be used i) to clarify certain aspects of land treatment technology, e.g., maximum application rates on various soil types, the impact upon industrial pretreatment costs and the feasibility of various types of agricultural operations and ii) to familiarize the public with the potential benefits of land treatment. A final decision should not be made until the end of the 7 year period. The decision should be based upon the new information which will then be available.

3. Before a final decision is made on a regional level additional attention should be directed toward:
   i) The possibility of treating stormwater to a degree below Level Two standards.
   ii) The completion of a sensitivity analysis designed to measure the impact of potential system adjustments necessitated by projection errors.
4. On a national level consideration should be given to the staggering of compliance dates for the achievement of the new water quality standards.

2. Ecological Analysis

a. Introduction

The evaluation of the final wastewater management alternatives is based on attributes that characterize mature, stable, and healthy ecosystems. These parameters have been defined and their importance described in previous sections of this report.

The impact of plans A, B, and C will be discussed in terms of effects on ecosystem energetics, structural components of biological communities; nutrient cycling; life histories of component organisms; selection pressure against potential species; and overall homeostatic control mechanisms for major ecosystems affected by each of the wastewater management plans. The major ecosystems affected include streams and rivers within the Three Rivers Watershed; streams and rivers with the North Central Ohio land treatment area; land treatment sites within the Three Rivers Watershed; land treatment sites in North Central Ohio; stripmined lands in Eastern Ohio; and Lake Erie.

In general, the waterways within the Three Rivers Watershed will be affected by changes in hydrology, removal of domestic and industrial wastes, and by channel modifications. Waterways within land treatment areas to the west will be affected by increased discharge, change in chemical composition, and channel modifications. The magnitude of these effects and the specific location of maximum environmental impact will vary from plan to plan.

Land treatment sites within the Three Rivers Watershed and sites in North Central Ohio will be primarily agricultural lands. Changes in agricultural patterns and farm management practice will be required

under certain wastewater treatment alternatives. Soil texture, structure, fertility, and biota also will be affected. Stripmined areas in Eastern Ohio will require specialized land management practices.

Lake Erie will be affected by changes in the chemical composition of the tributary waters. This will include a reduction in the quantity of plant nutrients such as phosphates and nitrates entering the lake. Some elements such as sodium and chlorides may increase. The quantity of sediments entering the lake also will vary depending upon the wastewater management plan adopted. The total quantity of water entering Lake Erie will remain relatively unchanged regardless of the plan adopted, but the quantity of water entering particular points along the lake shore will vary from plan to plan.

b. Ecosystem Energetics

(1) Consumption of irreplaceable natural resources such as fuels, chemical coaggulants, electrolytes, and absorbants. After 1990 plan C will consume less than one half of the amount of chemicals as required for plans A and B. The environmental impact on areas outside the Three Rivers Watershed that supply the chemicals, therefore, will be considerably less under plan C than either of the other plans. The magnitude of the enviromental impact to areas supplying wastewater treatment chemicals cannot be accurately assessed within the scope of the present enviromental scan.

(2) Consumption of electrical power. Plan C will consume more than twice as much electrical power as either of the other plans. The annual electrical power consumption after 1990 will be approximately the same for plans A and B.

Most of the electrical power will be produced outside of the Three Rivers Watershed. The magnitude of the environmental impact to areas supplying electrical power cannot be accurately assessed from the information supplied. Methodology for evaluating the impact of electrical power production is poorly developed at this time.

(3) Balance between Productivity and respiration (P/R ratios).

Productivity/respiration ratios approach one (1) in most natural ecosystems. In agricultural ecosystems and newly reforested areas it is considered desirable to increase productivity so that the ratio exceeds one. In aquatic ecosystems, however, both high P/R ratios and low ratios lead to undesirable effects. If productivity greatly exceeds the ratio of respiration massive blooms of algae and excessive growths of aquatic vascular plants often accumulate in waterways rendering them unfit for recreational uses or for domestic water supplies. If excessive quantities of decaying organic materials such as untreated or partially treated sewage is emptied into a waterway, the P/R ratio declines to much less than one. This situation often is accompanied by toxic conditions and oxygen depletions that destroy many desirable forms of aquatic life.

(a) Effects on rivers and streams of Three Rivers Watershed. -

All three plans should greatly improve the present balance between productivity and respiration in aquatic ecosystems within the Three Rivers Watershed. Imbalances in P/R ratios presently created by the discharge of poorly treated sewage below Akron, Cleveland Southerly, and several other municipalties should be improved significantly under each plan. A greatly enlarged evaluation program would be

required to accurately determine the degree of difference in improvement in P/R ratios that could be expected from each plan.

(b) Effects on rivers and streams in North Central Ohio. -

Only plan C will have an impact on the productivity/respiration ratio in areas to the west. If the amount of phosphates now entering streams in this region can be reduced, then a more favorable P/R balance will be achieved. Otherwise, the flow of nutrients and the increased flow of water in streams of the out-of-basin land treatment area may increase algae and vascular plant productivity to an undesirable level.

(c) Effects on agricultural lands in the Three Rivers Watershed -

Since an increase in productivity over respiration is usually regarded as highly desirable for agricultural systems, then plans B and C should produce the more beneficial effects on agricultural lands within the Three Rivers Watershed. Plan A will have no effect on the P/R ratio of agricultural lands.

(d) Effects on agricultural lands in North Central Ohio. -

Plan C should enable farmers to maintain high P/R ratios for their crops without the addition of commercial fertilizers. Plans B and C will have no impact on the balance between productivity and respiration in this area.

(e) Effects on Lake Erie. -

In recent years increased nutrient inputs into Lake Erie have greatly accelerated productivity within the lake. This has led to undesirable algae blooms and to the replacement of desirable species of aquatic life with more undesirable organisms. The amount of phosphate discharged into Lake Erie appears to be approximately the same for each plan. The impact of this nutrient discharge on productivity in

Lake Erie, therefore, would be approximately identical under each plan.

(4) Maximization of the return of humic materials (sludge) to ecosystems of origin. Organic sludges are the principle humic materials generated in each wastewater treatment plan. Plan C will maximize the return of this material to land areas where it can be used most beneficially as a soil conditioner. Under plan B moderate quantities of sludge are returned to land areas within the basin. Incineration of sludge as proposed under Plans A and B is extremely unwise from the ecological viewpoint.

(5) Production of effluent that requires additional labor and fossil fuel inputs (energy supplements) to maintain stability in receiving agricultural and aquatic ecosystems. Plan A will require the least additional labor and supplementary energy for maintaining the stability of receiving ecosystems. Plan C will require extensive inputs of labor and energy to maintain agricultural areas to the west and to prevent over-fertilization of waterways in this area.

In sufficient information is not available to adequately assess the magnitude of the additional labor and energy requirements that will be generated under plan C.

c. Ecosystem Structural Components

(1) Maximization for diversity of aquatic life.

(a) *Effects on aquatic life within the Three Rivers Watershed.*- The diversity of aquatic life in the Rocky River, middle and lower Cuyahoga River and the Chagrin River should be improved considerably under each plan. Most studies of benthic invertebrates within the watershed indicate that in the most heavily polluted areas up to

95% of the species have been eliminated. A comparable reduction in the number of fish species also has occurred. Most of the missing species probably can be restored if the quality of effluent proposed under each plan can be achieved.

The magnitude of improvement in diversity cannot be accurately forecast at this time because of insufficient knowledge of the effects of various chemicals, mixtures of chemicals and interaction of chemical substances with physical factors on the thousands of species of aquatic organisms indigenous to the Three Rivers Watershed.

The effects on aquatic life of slight differences between plans in the discharge of BOD, phosphate, ammonia, and suspended solids cannot be determined with present methodology.

(b) Effects on aquatic life in Lake Erie. -

The effects of Three Rivers water on the diversity of aquatic life are most noticeable in the near-shore areas around Cleveland where the diversity of benthic organisms and fish is especially low. The diversity of these organisms should improve considerably in this region if the quality of effluent proposed under each plan can be achieved. It is not possible to distinguish between plans with regard to the degree of improvement of diversity expected from each plan.

d. Nutrient Cycling

(1) Maximization for recycling of phosphorus and nitrogens. Plan C is the only plan with extensive provisions for recycling of plant nutrients such as phosphorus and nitrogen. Some recycling of these elements will take place within the basin under Plan B. Plan C also maximizes for ensuring biological control of nutrient cycles. Reuse of organic sludges as soil conditioners also is maximized under

Plan C. Plans A and B will generate large quantities of inorganic sludges with very poor reuse potential. After 1990 Plans A and B each will generate approximately three times as much inorganic sludge as Plan C, although the inorganic content will be somewhat less in Plan A to Level One.

(b) Maintenance of natural hydrologic regimes. Present hydrologic regimes in the Three Rivers Watershed will be least disrupted under Plan A.

The major changes will occur in Tinkers Creek and the lower Rocky River where as much as 50% of the present flow is maintained by effluent from wastewater treatment facilities. Consolidation of these wastewater facilities with large regionalized plants farther downstream will greatly reduce the flow in certain sections of Tinkers Creek and the lower Rocky River. Under Plan B the flow of water in the Rocky River and the upper Cuyahoga will be partially augmented by drainage from in-basin land treatment areas. Major alternations in hydrologic regimes will occur under Plan C. The discharge of streams in the vicinity of Cleveland that are presently augmented with water from Lake Erie through the Cleveland water distribution system will be reduced by at least 50%. The annual discharge of the Sandusky River in North Central Ohio will be doubled by the year 2000.

Disruption of present hydrologic regimes under Plan C will have two major effects on Lake Erie.

(1) The amount of sediment transported into the lake will increase approximately four times. At present 85% of the water used within the Three Rivers Watershed is taken from Lake Erie, used in the vicinity of Cleveland, and returned near the mouths of local streams close to Lake Erie. Very little of this water comes into contact with

the land where soil particles would be removed and transported into Lake Erie.

Under Plan C most of the water obtained from Lake Erie would be transported to the west where it would be percolated through the soil. Despite elaborate erosion control measures substantially larger quantities of soil would be transported into Lake Erie than occurs under present conditions.

(2) The location of the point of discharge for at least half of the water entering Lake Erie from the Three River area would be changed. At present most of the discharge from the Three River Watershed occurs in the vicinity of Cleveland. Under Plan C approximately half of the present annual discharge would enter Lake Erie near the mouth of the Sandusky River in North Central Ohio. The ecological implications of this change in discharge location are difficult to evaluate and should be studied further.

e. Life History

(1) Development of a great variety of ecological niches, stimulation of populations or large organisms, and encouragement of species with long, complex life cycles.

This parameter is most applicable for aquatic habitats within the Three Rivers Watershed and for Lake Erie. The parameter does not apply to agricultural ecosystems where ecological niches and the kinds of organisms present are maintained by human labor and energy supplements from outside the system. Each of the plans should improve substantially the variety of niches available within the streams and rivers of the watershed and in Lake Erie. The magnitude of these improvements cannot be determined within the scope of this evaluation.

Further studies also would be required to distinguish, between plans, any differences expected in the development of ecological niches and species with long, complex life cycles.

f. Selection Pressure

(1) Control of nuisance organisms such as mosquitoes, house flies, midges, sludgeworms, aquatic weeds, and bluegreen algae. Elimination of toxic conditions in the middle and lower Cuyahoga River as indicated under each of the plans may actually encourage nuisance organisms such as mosquitoes and midges. The reduction of toxicants also could allow an increased growth of aquatic vascular plants and algae in the rivers and streams. Lakes within the basin would be relatively unaffected. The growth of aquatic vegetation would be especially large unless phosphate levels in the waterways could be maintained well below 0.5 ppm. This is an unlikely possibility because of the large number of septic tanks within the watershed and because of the large quantities of phosphates entering the streams from stormwater runoff.

The construction of sewage lagoons within the watershed under Plan B and in western Ohio under Plan A would increase the breeding areas for mosquitoes. The range of these organisms, however, would be confined to relatively short distances from the lagoon margins.

g. Overall Homeostasis

(1) Rehabilitation of terrestrial ecosystems that have been destroyed or badly disturbed while supplying resources to the Three Rivers Watershed.

Relatively small quantities of sludge will be transported to Eastern Ohio for the rehabilitation of stripmined lands under either Plan A. Amounts will be increased considerably after 1990.

Plan B is similar to Plan A, using incineration and moderate quantities of sludge to apply to agricultural lands and stripmine areas. Transmission to stripmine areas will increase after 1990. Plan C will dispose of sludge by incineration and some application to agricultural land up to 2000. After that, sludge previously incinerated will be removed at the land treatment areas to the west. No application is made on stripmined areas. The important enviromental problem represented by stripmined areas should receive more attention in each plan.

(2) Conversion of terrestrial ecosystems into aquatic ecostems.

Under Plan C, the conversion of land areas into sewage lagoons and winter storage facilities will greatly exceed the conversion under Plans A and B. Since most of the converted areas will be agricultural lands in western Ohio, studies should be made to determine if the loss in agricultural productivity due to land conversion will be compensated by increased crop yields on the adjacent land treatment sites. Present plans are not detailed enough to make these estimates.

(3) Protection of plant and animal life (including human life) from possible cumulative toxic effects of heavy metals or other harmful industrial and agricultural chemicals.

Plan C with its strong emphasis on land treatment would raise the most serious possibilities of long-range toxic effects from heavy metal accumulation through agricultural food chains. Recent studies with sludge disposal on agricultural lands at the University of Illinois indicate that toxicities to crops and animals on a

short-term basis probably will not be a serious problem. The long-term effects, involving accumulation of heavy metals in humans, however, have not been adequately studied. Also the sludges used in the University of Illinois studies did not contain large quantities of industrial wastes.

Early action programs should be initiated in Ohio to determine long-range, cumulative effects of heavy metals applied to agricultural lands. Wastewater and sludges from the Akron and Cleveland industrial areas should be used.

F. Individual Plan Evaluation

The twelve alternate plans previously evaluated have, in this final section, been reduced to three for a detailed cost analysis and time phasing. The three selected for further investigation by the Corps of Engineers and the Ohio Environmental Protection Agency were originally designated Plans 1, 7 and 8. However, modifications have been made in these original plans and the new related designations are Plan A, Plan B, and Plan C.

The twelve alternate plans reviewed in the previous section, were not all designed to meet the same pollution control standards. However, all new plans are designed to achieve a Level Two effluent by 1985. Level Two is based upon the Corps of Engineers interpretation of the national goal identified in the Water Pollution Control Act of 1972. In addition to the detailed Level Two planning, Plan A has been costed to a Level One effluent (state standard) to provide comparative data indicating the cost of achieving the higher water quality.

Modifications, directed toward optimization of the three plans, have been made in the treatment of stormwater and in sludge handling techniques. Further changes have been made in the land treatment, where aerated lagoons have generally replaced conventional secondary treatment and high rate effluent applications have replaced a more conservative approach.

1. Plan A - Level One

(a) General Description

Plan A is similar to Plan 1, which was in turn, a modification of the Northeast Ohio Water Development planning, based on higher effluent standards and incorporating stormwater treatment. Twenty-six plants are proposed, eighteen of them new, and all discharging to water. Twenty-three will be biological treatment systems while three are physical-chemical. These include a new Kent plant, Rocky River, and Cleveland Westerly. Digested sludge will ultimately be applied to strip mined areas or local agricultural areas, but major amounts are incinerated up to 1990 and physical-chemical plants will continue to do so.

Plan A, Level One and Plan A, Level Two have the same facilities and locations. The particular consolidations and degree of regionalization was optimized for the Level Two cost and "may not be optimized for the Level One cost." Nevertheless, approximately 43% of stormwater will be treated in municipal plants during off peak hours and 81 separate stormwater treatment plants will treat the balance.

The regionalization is most evident in the Rocky River Basin where only two plants are projected. Wastewater will be removed from both the East and West Branch of the Rocky River and transmitted to the Cleveland Southerly plant.

(b) Ecological Considerations

Reference is made to the ecological analysis beginning on page 427. Plan A-1 requires considerable input of power and resources for operation. As a Level One plan, it does not contribute to a stable P/R ratio (the ratio of gross production to total community

respiration as probably one of the best functional indexes of the relative maturity and stability of the ecosystem), and provides little encouragement to aquatic diversity, ecosystem maturity, and organism inter-relationships. It requires little disturbance of terrestrial ecosystems but must be downgraded on its comparative protection of life from the potential of toxic materials and viruses.

(c) Resource Demands

The power required in Plan A-1, for the achievement of Level One treatment standards by the year 2020 will amount to 2105 megawatt hours daily, about 87% of that required by Plan A-2. At the current cost of $0.0121 per KWH, the daily cost would amount to $25,470.00. The chemical requirements for treatment will be about two-thirds of that for Plan A-2, but will still amount to about 700,000 pounds per day in chlorine (125,800 lbs.) alum, lime and polymers. The future environmental and economic costs of energy production and resource demands are discussed in Attachment G.

(d) Reliability

Reference is made to the reliability of the biological treatment method on page 298 and to the procedure of treating stormwater in the low flow periods of municipal plants on page 321. The effectiveness of the tertiary treatment is of course dependent on the adequacy of the secondary treatment and failure of this section of treatment can lead to temporary deterioration of the entire process. The treatment process is not expected to remove the viral hazard and some flow through of toxic metals and refractory organics will be present. A system failure would result in the current practice of spilling untreated wastes into the streams and Lake Erie. In

addition to the biological process, there are unanswered questions about the capability of large scale physical-chemical plants to meet required standards consistently and the reliability of a system treating stormwater and municipal flows is unknown.

(e) Land Use Changes

The proposed land requirements would include space for a 500-foot buffer strip around each municipal treatment plant. The requirements for acreage include 720.5 acres for wastewater and 1,740.6 for stormwater, totalling 2,470.1 acres. No land treatment acreage is required, however, the incineration of about 290 tons of sludges daily will require landfill acreage and present problems of denial of other usage and various esthetic consequences. The acreage assigned to stormwater collection, will under current plans be unavailable for alternate recreational use because of intermittent water levels. They will constitute an attractive nuisance and possibly a health hazard as well, though fluctuating water levels should inhibit insect growth. Consideration should be given to flow control to allow minimal recreational use, during the winter months for ice skating, for instance. There are a number of active and passive recreational uses possible in association with treated stormwater, other benefits to be gained from flow control and a totally unexplored potential for local industrial use even though treatment would produce a non-potable water. In other aspects, improved water quality may be expected eventually to enhance the potential of the adjacent land.

f. Public/Political Perceptions

Plan A-1 is established on a relatively firm base of state water resources planning and the Three Rivers Watershed District. With this precedent, the various pressures of regionalization, and the 1972 water quality law, there appear to be no insuperable institutional barriers. Continued public environmental concern will assist in the realization of a plan as will the comparative Level One cost factors. The failure to recycle residuals, and the lack of multiple use opportunities may be detrimental.

g. Flexibility

The Level One treatment system is essentially a conventional activated sludge plant with add-on units for removal of specific pollutants. The current requirement to meet Level Two standards by 1985, could therefore be met by process additions or by conversion in some instances to land treatment. Physical-chemical plants are not as readily adaptable. The plan for the Southwest interceptor is a major commitment which would severely inhibit subsequent changes in the Rocky River Basin. The flexibility of stormwater treatment is a cause for concern. If eventually it is decided that stormwater treatment may remain at Level One, either permanently or until a later compliance date, there will be no way of separating the combined flows and over capacity may result in the system.

h. Stormwater Management

Reference is made to the discussion of the level of stormwater treatment on pages 302-303. There is a major question whether Level One stormwater treatment can be optimized by combined treatment

in municipal plants as opposed to the multiple values in localized treatment and discharge and the elimination of both hazards and sizing problems in municipal plants.

(i) Residuals

The residuals from Plan A will include over 580 dry tons of sludge by the year 2020 from municipal plants, and sludge from stormwater collection basins. The sludge from the collection basins will be disposed of by recycling for topsoil or fertilizer or put into landfill.

(j) Disposal Methods

Until 1990, two-thirds of the available sludge will be incinerated, less than 3% will be sent to strip mines for reclamation work, and the balance will be applied locally to agricultural land. Inasmuch as costs, both economic and environmental are generated by incineration, the destruction of an irreplaceable resource, and the loss of benefits in reclamation should be carefully considered. From an environmental point of view, incineration should be phased out as rapidly as alternate means can be developed to recycle the sludges.

(k) National Objectives

Consideration of national and regional objectives for Plan A-1 will be similar to Plan A-2 and will be considered following Plan A-2 discussion. The one obvious dissimilarity is the failure of this plan to meet a national objective as expressed in the Federal Water Pollution Control Act of 1972, which stated in Section 101a that "it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985." Plan A-1 is a plan not to meet that goal.

2. Plan A - Level Two

(a) General Description

Plan A-2 is similar to Plan 1, which was in turn a modification of Northeast Ohio Water Development planning, based on higher effluent standards. Twenty-six plants are proposed, all discharging to water. Twenty-three are advanced biological systems while three are physical-chemical. These include a new Kent plant, and Rocky River and Cleveland Westerly. Digested sludge is ultimately applied to strip mine areas or local agricultural lands, with residuals from physical-chemical plants being incinerated.

Stormwater treatment has been optimized to take advantage of the available capacity in municipal plants. Eighty-one separate advanced stormwater treatment plants are designed to treat about 57% of the runoff.

Plan A-2 is highly regionalized, particularly in the Rocky River Basin where only two plants will remain after 1990. The Southwest Interceptor will then divert flows to Cleveland Southerly. Regionalization is more limited in the Chagrin and Cuyahoga River Basins.

(b) Ecological Considerations

Reference is made to the ecological analysis beginning on page 427.

(c) Resource Demands

The power required in Plan A-2, for the achievement of Level Two treatment standards by the year 2020 will amount to 2414 megawatt hours daily. At the current cost of $0.0121 per KWH the daily cost will be $29,209.00. The chemical requirements for treatment will amount to 962,400 pounds per day in chlorine (105,200 lbs/day), alum, polymer, methanol and lime. The environmental and economic costs of energy production and the economic factors in resource demands are discussed in Attachment G.

(d) Reliability

Reference is made to this section on pages 298 and 321 relating to the effectiveness of advanced biological treatment being dependent on the adequacy of secondary treatment and the competency of personnel. Viral hazards are not expected to be completely eliminated in this treatment. There are also unanswered questions about the capability of large scale physical-chemical plants being able to meet the required standards consistently. The experience is lacking. System failure, in water based treatment, may result in the release of untreated wastes to water. The reliability of a system treating stormwater with municipal flows is also unknown since it has not been previously tried on this scale.

(e) Land Use Changes

The proposed land requirements would include space for a 500-foot buffer strip around each municipal treatment plant. The requirements for acreage include 720.5 acres for wastewater and 1,740.6 for stormwater, totalling 2,470.1 acres. No land treatment acreage is required, however, the incineration of about 290 tons of sludges daily will require landfill acreage and present problems of denial of other usage and various esthetic consequences. The acreage assigned to stormwater collection, will under current plans be unavailable for alternate recreational use because of intermittent water levels. They will constitute an attractive nuisance and possibly a health hazard as well, though fluctuating water levels should inhibit insect growth. Consideration should be given to flow control to allow minimal recreational use, during the winter months for ice skating,

for instance. In other aspects, improved water quality may be expected eventually to enhance the potential of the adjacent land.

(f) Political/Public Perceptions

Reference is made to the discussion of institutional aspects in Attachment II and the section beginning on page 300. Plan A-2 as Plan 1, begins from a relatively solid based state planning, within an area where regionalized planning, if not management, has been accepted. However, the acceptance of the local portion of costs involved in achieving a Level Two effluent will depend in some measure on the level of environmental concern, the incremental costs above previous treatment levels and the demonstration of environmental need subsequent to the achievement of earlier levels. Plan A-2 is hampered to some extent by limited opportunities for reuse, recycling and alternate uses in the process and facilities selected.

(g) Flexibility

The advanced biological system used in most plants is essentially a conventional activated sludge plant with add-on units for removal of specific pollutants. Changes in the quality of influent or effluent can be met by process additions or by conversion to land filtration. The system is relatively inflexible for resizing to meet an increase or reduction in hydraulic flow. The plan for the Southwest interceptor is a major commitment which would inhibit subsequent changes in the Rocky River Basin. If it is eventually decided that stormwater does not require the same level of treatment as sanitary waste, there will be no way of separating the combined flows. The

cost of stormwater treatment may be so great as to delay its phasing until after the sanitary system, resulting in plants with a major overcapacity. The costs involved in a Level Two system are such that conversion to other systems would be most unlikely.

(h) Stormwater Treatment

Reference is made to this section on page 302 and 323.

(i) Hydrologic Effects

Reference is made to this section on page 304, relating to Rocky River flows. In general, the diversion of stormwater downstream to regional plants is expected to reduce the flow in several reaches of the various streams.

(j) Residuals

The residuals from Plan A will include over 580 dry tons of sludge by the year 2020 from municipal plants, and sludge from stormwater collection basins. The sludge from the collection basins will be disposed of by recycling for topsoil or fertilizer or put into landfill.

(k) Disposal Methods

Until 1990, two-thirds of the available sludge will be incinerated, less than 3% will be sent to strip mines for reclamation work, and the balance will be applied locally to agricultural land. Inasmuch as costs, both economic and environmental are generated by incineration, the destruction of an irreplaceable resource, and the loss of benefits in reclamation should be carefully considered. From an environmental point of view, incineration should be phased out as rapidly as alternate means can be developed to recycle the sludges.

(1) Regional Development

There is a major question whether the development of water resources can influence population growth or redistribution and economic prosperity in a regional sense. Regional development is a complex economic and social phenomenon and no simple generalization is possible. While historically, regional development in the West has been encouraged and made possible by water projects, its significance is now reduced. At the present time, national water policy does not appear to be a way to influence the distribution of population. Growth today appears to be more related to location and access to metropolitan areas, a minimum concentration of population, a history of recent growth and an economic base including manufacturing.

The availability of water is neither a guarantee of economic growth nor a hindrance of in short supply. There are so many opportunities for water conservation and reuse, that the physical availability of water, beyond some minimal amount, has little influence on industrial location. Short-term economic gains such as the reduction of unemployment and the increase of local income from construction projects are seen but these disappear rapidly on completion of construction.

In the sense that water must be viewed as a scarce resource, the development of any factor such as wastewater treatment, will influence regional growth only when (1) market demands indicate that the goods and services that would be produced are needed by a growing economy, (2) substitutes for water related goods and services are not economically competitive in meeting these demands,

and only where (3) the competitive advantage is favorable, and (4) the region is willing and able to undertake complementary development activities. Any failure to recognize these requirements would result in projects without useful effect on regional growth, or one that merely relocates economic activity without a net gain to national development.

Regional development in the future will probably be shaped more by basic market forces and governmental policies. The tremendous growth of transportation and communications capability of the past couple of decades, have strengthened the influence of national and international markets on the economic growth in each of the nation's component regions. Witness the growth of multinational corporations within the past several years. Coupled with this is the influence of federal economic policies, and in some cases government purchases, on the regional economy. It must be indicated that any regional economic growth is increasingly dependent on the performance of the national economy.

The National Water Commission report, concludes that while water resources projects have had very significant effects in the past on regional economic development and population distribution, their role has now greatly diminished. It is their judgement, that national water programs should continue to accomodate future economic and population growth by responding to, rather than trying to influence development patterns.

To downgrade the importance of water resource management or the integral function of wastewater management, is not to indicate that there are no effects related to regional and

national goals. The effects and the potential effects are numerous. It must be noted that the potential effects are far larger, either because they are derivative and secondary or because the particular system plan did not develop the potential.

The contributive or detracting effects of the individual plans are outlined under the headings of regional development, environmental quality, social well-being and national development, following each plan.

The impacts on regional development of Plans A-1 and A-2, are as follows:

Increases in the cost of industrial waste treatment.

An employment of about 2000 persons for operation of wastewater systems, 17% higher for A-2.

An increase in land values along streams in basin because of water quality enhancement. The enhancement would be larger for A-2.

An increase in land value in strip mined areas for agricultural, recreational use.

A probable increase in tax base for both strip mined and water related areas.

An increase in power requirements which may relate to new plant needs, siting decisions and various environmental consequences, larger for A-2.

An increase in fuel needs, which may have national implications, requiring allocation and determination of priorities.

An increase in chemical demands, larger for A-2 which may have significant economic effects. Reference is made to Attachment G, for further discussion of energy, fuel and chemical requirements.

Short term increases in construction employment which will reflect national increases in material, equipment and supply demand.

Increased potential for meeting other water and related land needs as developed.

(m) Environmental Quality

Plant consolidation without redistribution of effluent will adversely affect the aquatic ecosystem in the Rocky River.

Plan A-1 does not meet the 1985 goals of PL 92-500, Plan A-2 does.

Plan A-1 will provide a somewhat improved aquatic ecosystem, leading to more desirable biota; improvement of all water uses. Plan A-2 will markedly enhance the above and probably lead to a reduction of algal contamination.

Plan A-2 will generally meet the demands of environmental groups on water quality, Plan A-1 will not.

Plan A-1 and 2 will increase the environmental and esthetic characteristics of strip mined land, providing an increase in annual habitat and other recreational potential.

Plan A-2 will increase the esthetic and recreational potential of stream associated land and lake shore areas. Plan A-1 will provide less improvement.

(n) Social Well-Being

Reference is made to Attachment I, Distributive Equity Impact of a Regional Wastewater Treatment System.

With its limited land use, Plan A will have a minor effect on social well-being in the basin, and none in outside areas.

Both plans will provide some degree of flood control through stormwater detention.

Both plans will provide the potential for recreational development at suburban water storage sites and in land corridors along streams. Plan A-2 stream potential is higher because of better water quality.

Regionalization affected by waste treatment is expected to encourage other cooperative arrangements among basin jurisdictions.

There will be a decrease in disposal income, greater for A-2, due to increase in sewer charges.

Improved water quality will contribute in degree to state programs in recreation, conservation and fishing programs.

Improved water quality, greater for A-2, will benefit public health in both potable and non-potable uses.

(o) National Economic Development

The short term construction employment will have multiple effects in industries providing equipment, materials and supplies.

Power requirements may impose a requirement for expansion of national energy production.

Price increase in manufactured items will result from increased waste treatment costs.

Some national income gains may result from recycling sludge nutrients in strip mine reclamation.

The potential for combination of sludges and selected solid waste for methane fuel generation cannot be dismissed. This also relates to national implications of fuel requirements for incineration and the need for priority determination and an allocation plan.

Reference is made to discussion, energy and other resources in Attachment G.

3. Plan B

(a) General Description

Plan B is a modification of Plan A, with certain proposed advanced biological plants being reduced to secondary plants with effluent given land treatment as the advanced section. The land treatment takes place within the basin, except for sludges transmitted to strip mine areas. Thirty-one plants are proposed, including nine advanced biological and twenty-two secondary plants, designated as aerated lagoons.

Stormwater treatment has been divided among the municipal plants using off-peak capacity, 39 advanced stormwater treatment plants and 46 separate stormwater land treatment sites. Sludge disposal is similar to Plan A and includes incineration and application to agricultural and stripmined lands.

Plan B reduces the regionalization evident in Plan A, replacing the one plant in the Upper Rocky River Basin with six secondary plants.

(b) Ecological Considerations

Reference is made to the Ecological Analysis beginning on page 429.

(c) Resource Demands

The power required in Plan B will equal 2,153 megawatt hours by 2020, at a current cost of \$26,051.00 per day. Chemical requirements, including chlorine, alum, polymers, lime and methanol would total 900,200 pounds per day. The environmental and economic factors in resource demands are discussed in Attachment G.

(d) Reliability

Plan B combines a Level Two water-based treatment with an increment of land treatment in the upper basins. Reference is made to page 320-321 for discussion of the reliability of advanced biological treatment and the untested procedure of treating stormwater runoff in slack periods of municipal treatment. There are questions about the capability of large scale physical-chemical plants to meet the required standards consistently, since experience is lacking. System failure, in water based treatment, results in the release of untreated wastes to water. In this system, the multiple plant operation and the land treatment increment have spread the risk considerably.

With reference to the land treatment section, attention is directed to the discussion of aerated lagoons in Attachment J. The ability of the aerated lagoon to produce secondary quality effluent under all conditions, few of which are under control of the operator, is open to question. Both the scale and the design pattern are untested and attract little confidence, since the "science" and design parameters of aerated lagoons are still largely empirical.

(e) Land Use Changes

Plan B emphasizes water disposal in a combined land/water treatment system, with land requirements confined to the basin. The acreage required for water-based municipal and stormwater treatment approximates 2800 acres. Land will be required, in addition, for aerated lagoons, treatment areas, and winter storage. At the 2020 flow rate, and based on conservative application rates (5 feet per year) and a 22 week winter storage

period, the total land area needed would be 28,000 acres. Lesser land areas, as indicated in the plans, will require a shortened winter storage period and a drastic increase in application rates, which may well eliminate the potential for conventional agriculture or even for public access, considering the soils in the basin. The advantages of high rate application must be compared to the advantages of multipurpose uses that otherwide might exist.

f. Public/Political Perceptions

The establishment of land treatment areas within the basin for the treatment and recycling of wastewater is considered essential to the success of further expansion to wider agricultural lands. This being the case, the gradual involvement of land proposed in Plan B seems appropriate. Land treatment techniques that inhibit multiple use, that require extensive government ownership, or that present negative visual images are unlikely to receive whole hearted support.

Preservation and enhancement of agricultural land from development and for agricultural production will be viewed favorably. Multipurpose techniques retaining the pattern of family farms to the extent possible, are both to be preferred to single purpose operations.

(g) Flexibility

The combination plan exhibits the most flexibility possible in a Level Two plan, particularly as it allows for the public adjustment to a change in the philosophy and direction of wastewater management. The land component has the potential for change to other systems or to changes in volume of wastewater.

(h) Stormwater Treatment

Reference is made to this section on page 302, regarding treatment of stormwater. The effluent will be released locally, either to land or water.

(i) Hydrologic Effects

No significant hydrologic effects are anticipated under this plan. Flow augmentation is practiced and detention storage will control flooding.

(j) Residuals

The residuals from Plan B will include about 548 dry tons of sludge by the year 2020 from municipal plants, sludge from stormwater collection basins, and sludge from aerated lagoons.

(k) Disposal Methods

Until 1990 approximately 70% of the available sludge will be incinerated, about 2% will be sent to reclaim stripmined land and the rest will be applied to agricultural land. From an environmental point of view, incineration should be phased out as rapidly as possible.

(l) Regional Development

Reference is made to the preliminary remarks under Regional Development on page 450, which indicates the limited influence of water resources development on the region. There are, however, specific impacts which are authored under the headings of regional development, environmental quality, social well-being and national development.

The impacts on regional development of Plan B are as follows:

Increases in the cost of industrial waste treatment.

An employment of about 2200 persons for operation of the wastewater management system.

Short term increases in construction employment which will be reflected in national increases in production of equipment, materials and supplies.

An increase in land values along streams enhanced by water quality improvement.

An increase in the tax base for water related land areas.

An opportunity for land reclamation is lost, as only 2% of sludges are assigned for reclamation of strip mined areas.

A potential exists for increasing crop and possibly beef or other livestock production in the basin.

Underdrainage and irrigation will increase crop production even in wetter years.

Increases the potential for retention of agricultural land in production, and provides resistance to development.

Increases potential fuel requirements for incineration and for drying crops grown in basin. Fuel demand may have national implications, with requirement for priorities and allocations.

An increase in power requirements which may relate to new plant needs, siting decisions, and various environmental consequences.

Potential net income gain on farms in basin.

An increase in chemical demands for wastewater treatment which may have significant economic effects. Reference is made to Attachment G for further discussion of energy, fuel, and chemical requirements.

(m) Environmental Quality

Increases potential for retention of open land in basin.

Will enhance the esthetic quality and recreational potential of streams and water related land and shore areas.

Will enhance the quality of the aquatic ecosystem, encourage more desirable species, improve all water uses and lead to improvements in Lake Erie including algal reduction.

Limits the opportunity to improve the environmental and esthetic quality of strip-mined land.

Will generally meet water quality demands of environmental publics.

Has a potential for change in the basin water balance, due to increase in evapo-transpiration and control of the ground water table.

Has a potential for increase in wildlife habitat areas near water storage ponds and for wildlife increase due to water related food improvement.

(n) Social Well-Being

Has undeveloped potential for recreational development associated with stormwater retention basins and in land corridors along streams. Potential also lost in strip-mined areas.

Enhancement of existing water-based recreation.

Decrease in disposable income based on the increase in sewage charges.

May contribute to state program development in recreation, fishing, and conservation goals.

Some degree of flood control provided through stormwater detention.

Regionalization effected for waste treatment will encourage other cooperative arrangements among basin jurisdictions.

There will be concern over socio-economic effects related to long term agricultural requirements, changes in current farming practices, and life styles.

Anxiety, related to government acquisition, use, or other conversion of local resources, particularly when related to "them" - the metropolitan problem.

High rate applications may require complete change in crops and community patterns and could prevent public access by a wet or otherwise unpleasant environment.

Reference is made to Attachment I, Distributive Equity Impact of a Regional Wastewater Treatment System.

Improved water quality will benefit public health for potable and non-potable purposes.

(o) National Economic Development

The short term construction will have national effects in industries supplying equipment and materials.

Price increase in manufactured items will result from increased waste treatment cost.

The potential for use of sludges or sludges combined with selected solid waste for bacterial production of methane fuel may become a reality within the time phasing for construction. This also relates to the national implications of fuel requirements for incineration.

Reference is made to the discussion on energy and resource availability in Attachment G.

The national concern for increased food production to reduce the balance of payments and to aid in U.S. foreign policy "detente" may be the strongest national relationship with land treatment in the next few years. Crop production will be accommodated to national needs rather than single purpose sewage treatment.

Plan B meets the requirements of Public Law 92-500.

4. Plan C

(a) General Description

Plan C is a combination plan with almost total emphasis on land treatment at its final phasing in the year 2000. Due to delays in the construction of an effluent tunnel to North Central Ohio, the system begins with eight advanced biological plants in the lower basin, shoreline areas, an advanced biological plant at Akron, and twenty-three aerated lagoon/land treatment facilities in the upper basins. The effluent tunnel is expected to be completed in 1985 to transmit major amounts of sanitary and stormwater wastes to aerated lagoons in the "Western" Land Treatment area. The tertiary water-based plants, meeting Level Two requirements, could be phased out between 1985 and 2000. The Akron plant would remain as an advanced biological plant, providing flow augmentation to the lower Cuyahoga.

Eventually, 69% of sanitary sewage and 55% of stormwater runoff would be transported to a single land treatment site in North Central Ohio. The site covers about 180 square miles at the juncture of Crawford, Huron, Richland, and Seneca Counties.

Stormwater treatment would be at the western land site by in-basin aerated lagoons, by advanced stormwater treatment plants, and in combination at the Akron plant.

Sludge disposal will be accomplished by incineration and direct application from aerated lagoons to agricultural land or other land treatment areas. Over 60% of sludges will be incinerated through 1990. No concern is given to strip mine reclamations.

(b) Ecological Characteristics

Reference is made to the ecological analysis beginning on page 427.

(c) Resource Demands

The energy requirements for Plan C in the year 2020, are approximately 2.5 times the requirements for Plan A. The principal demand is occasioned by the requirement for pumping of effluent from the tunnel and for constant aeration in lagoon treatment. While not envisioned by this report, some consideration should be given to a tunnel size that would allow storage on grade during hours of peak energy demand, pumping only in off-peak hours. The integration of the tunnel into a pumped power system should also be investigated. Chemical requirements for Plan C are about one-half of that for the other plans.

(d) Reliability

Reference is made to the discussion on aerated lagoons in Attachment J and to the reliability section of Plan 12 on page 375. As in Plan 12, Plan C introduces a number of innovative techniques and combinations thereof. Unfortunately, there is little reported experience to confirm the reliability or the efficiency of some of these techniques. Indeed, there are some expert contrary opinions.

Among the questionable techniques are the transmission of raw sewage, the use of aerated lagoons to achieve secondary effluent quality without acknowledging the necessity for extreme flexibility in this climate, and the use of high rate effluent applications in an overland runoff infiltration technique. The transmission of raw sewage over long distances can create conditions inimical to the

pipe structure. The high BOD temperature and the long travel time can create septic conditions leading to sulfide evolution in addition to the obvious sulfate corrosion. The effect of these products when discharged needs the consideration and the reliability of a single tunnel and pumping arrangements under these circumstances must be questioned. The lack of alternatives to dumping raw sewage in the lake in the case of transmission failure is unfortunate.

The aerated lagoon is discussed at length in Attachment J, but the known inability to control the quality of the effluent, the unusual sizes, depths and sequence of the lagoon system, the adequacy of a slow speed aeration system given the dimensions and an established holding period, and the influence of temperature on holding times all need further checking.

The efficacy of high rate applications of effluent by an overland runoff/infiltration technique is seriously questioned by members of the evaluation team. The proposed application of 90-150 inches per year to Mahoning-Ellsworth soils would require that the land be publicly owned open space. If the effluent rate is too high for irrigation, continued wetness and odor would bar public use and require increased acreage for lower application rates. Such acreage is not available.

(e) Land Use Changes

Plan C has attempted to maximize the land treatment in-basin and even with use of high rate application will require over 38,000 acres. About 160,000 acres will be required for treatment, storage, and irrigation at the western land site. The single-minded cost orientation of the enclave concept in this western area

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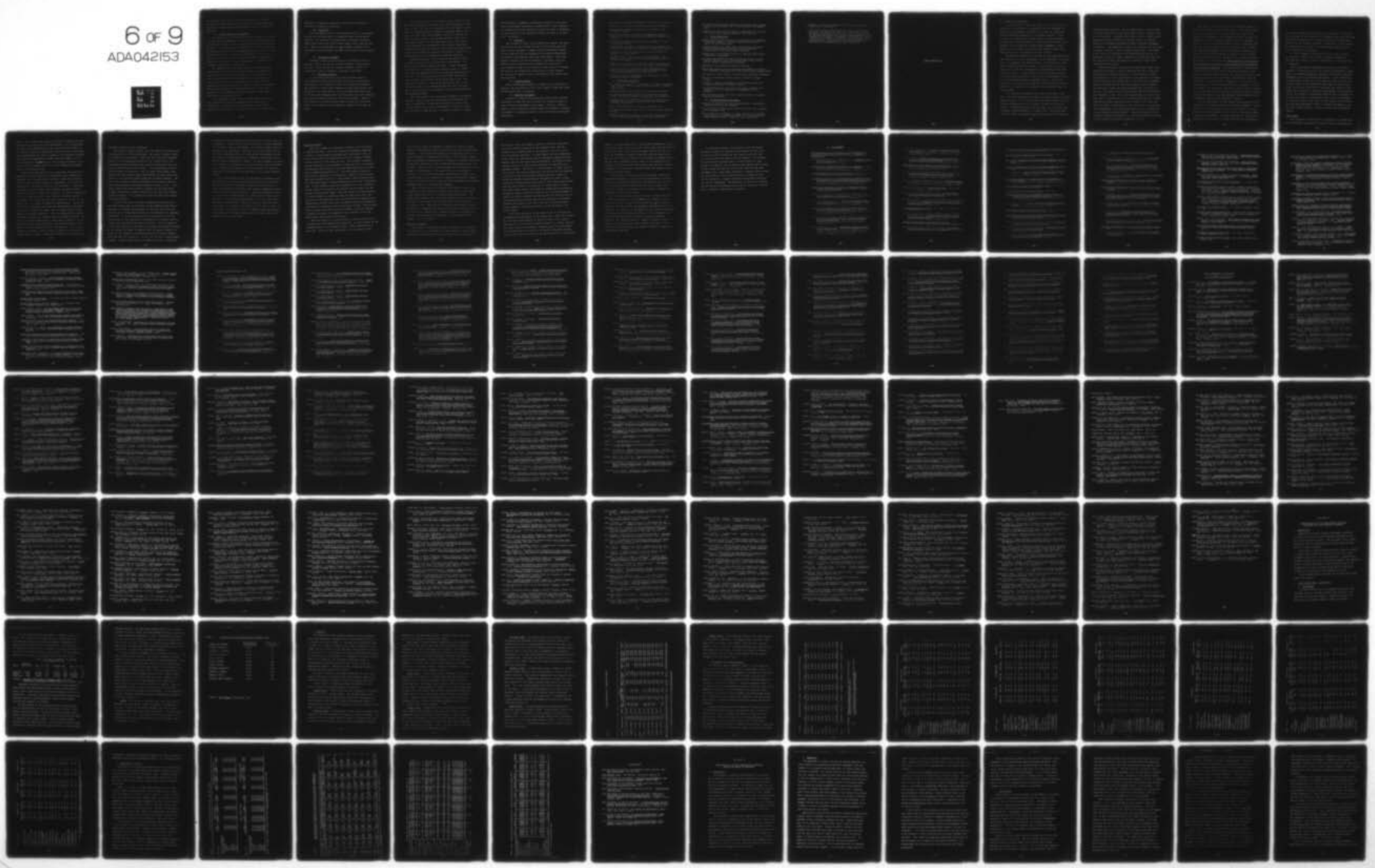

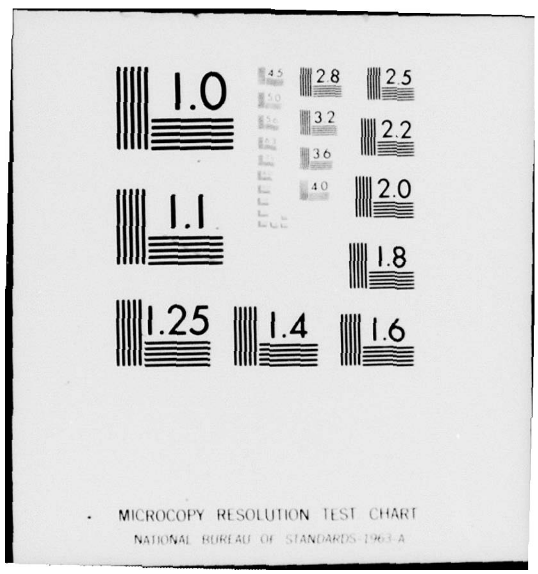
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is discussed in the final section of this report, but it will obviously be highly disruptive of community life, individual homes and farms, the agricultural pattern, and the tax base of the area concerned.

(f) Public/Political Perceptions

If a plan were to be calculated to create the maximum of public resentment and intransigence, it would have to incorporate many of the features of Plan C. This is highly unfortunate since the early acceptance of wastewater recycling and the use of waste nutrients in agricultural production has suddenly become of critical importance to the United States. Agricultural productivity is a critical factor in the maintenance of a reasonable balance of payments, an element in our current foreign affairs policy of "detente", and a counter-inflationary element at home.

The transmission of raw sewage, the use of aerated lagoons exclusively, the disruption of current patterns of farming and country life, the obvious interference of "big government", all have alternate measures that would preserve a lower public profile, avoid an instinctive antagonism, and at least afford an opportunity for the discussion of a major land plan on its merits.. The cost effectiveness of a non-acceptable plan is zero and it remains to be seen whether acceptable alternates would make a great deal of difference in cost.

It is true that the out-of-basin transmission will run into major problems of political accomodation and administrative coordination. However, given the appropriate climate, these problems can be overcome. For further discussion of source of the

problems of acceptance, attention is directed to Attachment H, Political Acceptance of Innovation.

(g) Flexibility

The development of water-based treatment which is then phased out when the effluent tunnel is completed, seems an unnecessary rigidity. The retention of these plants as secondary treatment plants would retain the conservational aspects while reducing land use. There is no requirement for all secondary treatment to be conducted in aerated lagoons and there are excellent reasons against it.

(h) Stormwater Treatment

Reference is made to the discussion of treatment levels on page 302. While the efficacy of land treatment is unquestioned, the lack of reuse options for treated stormwater, either in a recreational sense or otherwise, represents a deficiency.

(i) Hydrologic Effects

The hydrologic effects in the western streams, noted in other land plan alternates previously discussed, are mitigated in some degree by the reduction in inter-basin transfer afforded by the retention of water-based treatment at Akron and extensive land treatment in the upper basins. The use of major additional areas of the Rocky and Cuyahoga Basins for land application will eliminate many low-flow problems caused by other all-land plans. However, the transfer of the flow from the Southerly plant may create the effect of an estuary in the navigational channel of the lower Cuyahoga.

The hydrologic effects in the north central river basins are due to the introduction of excess water and the drainage of large areas of land. The effect of drainage will be to lower the water table by accelerating the draw-down of the normal supply. The impact of return flow from irrigation would be to increase discharge to local streams. The maximum potential return flow is never greater than 15% of the mean annual flood. The used upground reservoirs as contemplated in the Northwest Ohio Water Development Plan and the release of water during low-flow periods would ease the problem considerably and would be a factor in reducing the erosion and sedimentation otherwise predicted.

An interbasin water transfer requires the physical transportation of water out of one river basin into another. The water one area gains, another area loses. In most instances, the transfer of a precious natural resource, water, is looked upon with some apprehension on the one hand and appreciation on the other. In the present case, both the Three Rivers basin and the North Central basins are not water short areas. The advantage in transfer for the North Central area lies in the nutrient content of the effluent and the fact that free drainage is offered as part of the bargain, in an area that typically has drainage problems.

While the State of Ohio historically recognizes the riparian doctrine there has been no interference with reasonable use. There is apparently no published information on state policy in this regard, and a recent investigation has failed to reveal any firm body of legal opinion. In practice, there are a number

instances where a community establishes a reservoir in one watershed and discharges wastewater to another basin. Such situations are recognized and even founded by the State so there is apparently no legal obstacle to the interbasin transfer of water or in this case - wastewater.

(j) Residuals

The residuals in Plan C will eventually be reduced from about 318 dry tons per day to about 244 tons from the Akron plant and other in-basin treatment. Sludges from the facultative lagoons are not quantified and are scheduled to be removed hydraulically and spread on agricultural land after chlorination. Since high quality effluents can only be produced if microbial solids are removed, since no process step is proposed for this nor for algal removal, either in the facultative pond or prior to storage, the reuse of the effluent for cooling water or other purpose, and the fate of organic solids on agricultural land remains somewhat uncertain.

(k) Disposal Methods

While conservational methods of disposal will eventually be applied, the incineration of 60% of the sludges through 1990 seems an unwarranted loss of resources.

(l) Regional Development

Reference is made to the preliminary remarks under regional development on page 450, which indicate the limited influence of water resources development on the region. There are, however, specific impacts which are outlined under the headings of regional development, environmental quality, social well-being and national development.

The impacts on regional development of Plan B are as follows:

Increases in the cost of industrial wastewater treatment.

An employment of about 1700 persons in operation of the wastewater system.

Short-term increases in construction employment possibly multiplied by local production of materials, equipment, and supplies.

An increase in land values along shores enhanced by water quality improvement.

An opportunity for land reclamation is lost as sludges are incinerated and none are scheduled for strip mine application.

A potential exists for increasing crop and livestock production of a vital nature.

A potential exists for a net gain in farm income. Underdrainage and irrigation will increase growing season and yield in wet years.

Potential is increased for retention of prime agricultural land in production and provides resistance to development.

An increase in power requirements which may mandate new plants, siting decisions, fuel and environmental tradeoffs and the possible need for priorities.

Reference is made to Attachment G for discussion of energy, fuel, and chemical requirements.

(m) Environmental Quality

Will enhance the quality of the aquatic ecosystem, encouraging more desirable species, improving all water uses, reducing algal growth.

Increases potential for retention of open space in basin.

Will enhance the esthetic quality and water-related land areas, eventually extending the same process to Lake Erie.

Provides major inter-conversion from land to water systems, charging the ecosystem, developing possible nuisance factors, insects etc.

Rejects the opportunity to reclaim strip mines land.

Will meet water quality goals of P.L. 92-500 and environmental groups.

Exhibits potential for change in area water balance with increased evapo-transpirations and lowered water table.

Has potential for wildlife habitat increase near water storage areas; wildlife increase due to water related food improvement.

Potential for power plant siting at storage ponds for cooling will remove future thermal pollution from Lake Erie.

(n) Social Well-Being

Extensive public concern related to land acquisition, community disruption, changes in current farming practices, and family and farm dislocation.

Extreme reluctance to commit local resources to treat metropolitan waste problem, especially when forgoing own desired land use and socio-economic pattern.

Concern over socio-economic effects of long-term agricultural commitments, requirements.

High rate applications may require complete change in crops, community patterns and could restrict public access by a wet or otherwise unpleasant environment.

Enhancement of existing water-based recreation.

Undeveloped potential for recreational development associated with stormwater retention basins and land corridors along streams.

Some degree of flood control associated with stormwater detention.

Decrease in disposable income based on increase in sewage changes.

Reference is made to Attachment I, Distributive Equity of a a Regional Wastewater Treatment System.

If regionalization can be effected for waste treatment, the potential for other cooperative arrangements will be enhanced.

Improved water quality will benefit public health for potable and non-potable uses.

(o) National Economic Development

Construction activity will have national effect in industries supplying materials and equipment.

Price increase in manufactured items will result from increased waste treatment cost.

The need for use of sludges, or sludge combined with selected solid wastes for biological production of methane fuel may become apparent within a relatively short time frame.

Reference is made to the discussion on energy and resource constraints in Attachment G.

Finally, the current and developing shortages of basic grains and other exportable food items, due to the need to reduce the balance of payments and to aid in the U.S. foreign policy of "detente" may provide the strongest encouragement for land treatment as an adjunct to production within the near future. A reorientation of Plan C to support farm production, rather than the present subordination of agricultural needs to wastewater will undoubtedly prove more successful.

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IX. SUMMARY AND CONCLUSIONS

It became obvious in the early stages of the project that the management of wastewater was inseparable from the management of water resources generally and that this in turn was inseparable from environmental management in its broadest context. As our research was conducted into various aspects of waste management we found many interrelationships or indications that current water problems can be solved only through proper management of other natural resources and the control of environmental insults that might appear to be far removed from water concerns.

Environmental management in the past has been compartmentalized into such areas as forest management, stream management, farm management, air management and numerous others. Such division of labor may be administratively useful but, if carried too far, the biosphere will suffer the consequences of optimization within narrow sectorial limits. In many respects the water and other portions of the watershed ecosystem are very elastic and many human practices can be accommodated without irreparable damage. On the other hand there are practices and usages that are potentially dangerous because of our ignorance or disregard of the tolerance limits of the ecosystem.

It is obvious that change occurs within ecosystems in many ways. But the consequences of change will depend on what is demanded from the system. It is essential that man concern himself with all resource production and its reliability and not just selective aspects. Population pressures and the energy use per capita limit the amount of maneuverability in resource use. The United States as well as other "developed" countries have grown at the expense of

"underdeveloped" countries. But the limitations of resources make it totally impossible to apply our present economic strategy to the rest of the world. A Michigan State study cites the salmon fishery-hydroelectric power conflict for the West Coast as an obvious example of the problems generated by poorly integrated management of resources. The generation of power has interfered with the return of another resource, a high, sustained salmon yield. Our concern in this project as well, must be to avoid maximizing the use of a particular resource or single component of an ecosystem since this will inevitably create some degree of instability within other components of the system.

Without dwelling at length upon the agricultural impacts and implications of Plan C it may be indicated that this country has developed great economic efficiency in crop production through concentration on a few limited species, - corn and wheat for example. The "efficiency" of this productivity is the result of a tremendous energy cost which includes the stabilization of pest outbreaks, the watering of crops, the mining and supplying of nutrients to the soil, the fabrication of farm machinery and the utilization of major amounts of fuel. We are only now beginning to realize that this type of "efficiency" is self-limiting; that there is a finite capacity to produce sustained yields of foods on the earth and only the length of time before we reach that limit is in question. The documentation of this particular point of view is growing but even now appears incontrovertable. A particular aspect of this problems, previously discussed, is a critical polluting factor and a major problem in wastewater management, as well.

The fantastic increase in the rate of phosphate mining, close to 900% in the past 30 years, bears witness to the critical importance of this material by its use in agriculture and the widespread use of detergents. As an element essential for life, its importance increases in direct relation to its low abundance in nature. It has been estimated that our supply of phosphate rock will last for less than 60 years at our current rate of mining. Since phosphate compounds are, for all practical purposes, noncyclical, our culture and economy is living in utter disregard for the welfare and even the existence of our future generations. This leads to the conclusion that <u>the conservation and recycling of the nutrients in wastewater, and particularly the phosphates, is of overriding importance</u>. The present practice that disperses a limited resource from a readily available wastewater concentration (8,000 ppb average) to very low concentrations in the lakes and ocean, where they are essentially unrecoverable, should be terminated as soon as possible. Although it is not part of this discussion, one is led to consideration of the inutility of the use of phosphates for detergents, not only for the cost that it imposes on the environment and on wastewater treatment, but for the relatively absurd choice that is being made between a "whiter white" and the extended food supply of our children's children.

For the same reasons, we must regard the continuation of the incineration of sludges produced in wastewater treatment as counterproductive, not only because of the loss of resources, but also because of the environmental insult to the air we breathe, that is currently uncontrollable. All three plans must be criticized in proportion to the amount of sludges burned and the maintenance of

the process beyond the necessary time for replacement. While the use of sludges for the reclamation of stripmined land, which has been extensively discussed in this report, may not be the highest and best use for the resources involved, it represents a conservational use combined with a solution of a current urban problem, until a better application is discovered.

As a final comment on the necessity of recycling resources, any treatment process which result in chemical combinations that make the wastewater resources unavailable for recycling, must be downgraded.

While emphasizing the importance and necessity of measures designed to conserve and recycle the resources represented in wastewater, the evaluation group has significant reservations about the methodology used in agricultural application. These reservations are specifically related to (1) the suggestion that the soil is infinitely capable of the segregation and storage of various heavy metals and that for this reason the land plans are capable of eliminating the necessity for industrial pretreatment; (2) the application of the effluent to agricultural lands at rates that appear to be beyond the limits of acceptability; and (3) the establishment of a massive enclave in the center of four counties for the treatment and land application of waste, a concept that appears to ignore, for economic reasons, a series of social and environmental impacts.

Heavy Metals

The occurrence of heavy metals in wastewater is primarily due to the discharges associated with various types of industrial pro-

cesses. Heavy metals will largely be present in solution but some fraction may be associated with organic matter. In the discussion of earlier land treatment plans, the presence of heavy metals in the effluents applied to agricultural soils were not as significant since approximately 80% would be removed by the secondary treatment and subjected to appropriate disposal with the sludges. In the land applications in plans B and C, the secondary treatment is limited to aerated lagoons, with 100% of both effluents and sludges applied to agricultural land.

While we are concerned with the conservation and recycling of phosphates and other nutrients in wastewater, other elements and compounds which are potentially hazardous rather than a requirement for life, also move through the environment. The world-wide dispersion of DDT within a decade is well documented. Significant quantities of lead, mercury, radio isotopes and various organic toxins are dispersed through air and water. As they are transported, it is well-known that part of the biological transport machinery is damaged. The effects are most often obvious at the end of a consumer chain, as a result of biological magnification. Various species of fish, shellfish, and birds have been reduced or decimated as a result. So far as is known, man has largely escaped injury from recycling toxic materials. There are exceptional incidences, of course, including the Minimata disease or mercury poisoning from fish and there are indications of antral cancer related to the use of snuff made from plant ingredients that have selectively concentrated significant amounts of nickel and chromium. There are increasing indications in the literature, relating the incidence of various types of chronic, debilitating disease, to the presence of

hazardous chemicals in the environment.

Very little is known, however, about the effects of recycling of toxic materials on the micro-organisms that enable nitrogen, sulfur, and carbon cycles to continue. Since the soil biota are intimately involved in the continuing operation of the "living filter," the aggregation of toxic materials over a period of time might well destroy the effectiveness of this method. It is acknowledged, that extensive research has indicated that the common agricultural crops grown in Ohio can tolerate large concentrations of heavy metals when applied to the land from sewage sludges and secondary effluent. However, just as there is limited information on the survival and continued effectiveness of soil micro-organisms on such a diet, very little research has been performed regarding the long-term effect of plant transmission of metals through the food chain into terminal consumer organisms. It is known that plants can selectively concentrate such materials.

It may be true that the direct environmental poisoning of humans that results from the discharge of toxic materials into the environment is currently insignificant, but the fact that there have been any cases of poisoning and death is an indication of an unhealthy environment. It is our position that the disposition of toxic materials onto the land represents a continuation of a process that has already been discredited when applied to water. There are apparently only three options in addressing the question of hazardous materials. We can continue to ignore the problem until it suddenly becomes obvious (as, for instance, the unforeseen problem of mercury methylation) and then try to solve it. So far, this has been an unsuccessful approach. Another tactic might be to apply our research capability

to identify harmful materials and prohibit their discharge into the environment. However, at the rate new chemicals are being developed and discharged into the environment, it is highly unlikely that this approach can be successful. There are 13,000 items listed in the 1972 toxic substances list, and it has proven unsuccessful for the Food and Drug Administration with a relatively more limited inventory of chemical materials to analyze. The final approach, of course, is to prohibit the discharge of any alien material into the environment. Prudence would indicate the latter approach as regards the introduction of unlimited industrial waste into the land treatment system.

From another point of view, the invitation to discharge hazardous materials to the land treatment system removes the incentive to save or recycle the materials involved until such time as resource availability or cost makes such recovery economically imperative in a world of finite resources. A guiding principle to follow is to begin any recovery process at a point where the material of interest is at its highest concentration. If there is any likelihood that a material will be needed or useful at some later time, it is foolish to disperse it or dilute it in the air, or water, or on the land. The recovery cost in a dispersed state would require the expenditure of far more energy, which, of itself, may not be available at the time of need.

Application Rates

There are a number of interrelated concerns in the discussion of application rates. One of the innovative techniques suggested is that of a "mini-border", overland runoff system which relies on both overland runoff and infiltration to treat secondary effluent at rates from 90 to 150 inches per year. The available literature and the experience of the evaluators in Ohio gives rise to questions regarding the effectiveness of such high application rates, particularly on Mahoning-Ellsworth soils. The mini-border technique requires public ownership of the land used. Though it would provide open space, greenbelt effects it would prohibit other productive use. Even park usage might be limited depending on the actual infiltration rate. If the effluent cannot move through the soil, the continued wetness during the irrigation period would restrict public use and provide a poor esthetic image. Since the amount of acreage required for land treatment is conditional upon the application rate, any reduction of the application rate necessitated after completion of a demonstration project would cause an immediate problem regarding the availability of alternate soils and increased acreage. Choices would have to be made which would effect the amount of possible in-basin treatment and require an expansion of the treatment area on the agricultural land in North Central Ohio.

While the efficacy of overland runoff treatment and that of infiltration have been demonstrated separately, the effectiveness of the combined process is not presently known. Again, demonstration is necessary. There are some indications in the literature of the

long-term persistence of pathogenic organisms in unsterile sludges applied to grasslands, as might be possible within the overland runoff technique. A third question relating to the application rate has to do with continual irrigation by drip tubes. The literature suggests that an intermittent drying period is essential to avoid the development of anaerobic conditions or other conditions that would clog the soil porosity. While the use of aerated lagoons has been discussed at some length in an attachment to this report and also in an analysis of Plan 9, the inevitable development and discharge of algae from aerated lagoons raises a question in regard to the possible clogging of the soil and the effect of algae in the distribution and irrigation equipment, both as to corrosion and clogging.

There is one final note relating to the amount of water being transported to the western agricultural lands and its relationship to the application rates in a relatively concentrated area. The change in the natural water flow of the Sandusky River, for instance, will have a considerable effect on the amount of erosion and on the aquatic biota. Many species of benthic animals require periods of low flow to complete their life cycles and the consistent increase in stream levels coupled with a probable increase in sedimentation from the increased water flow will have a serious effect on the aquatic life of this area.

The Enclave Concept

The concept of locating an "enclave" devoted to the treatment of wastewater in a section where the four counties of Seneca, Huron, Richland, and Crawford meet is open to question on several counts.

We recognize there are economic reasons for limiting transmission lines and therefore dispersal of the treatment areas, but this reliance on an economic point of view ignores a series of social and environmental questions. It would appear that the accumulation of any such area could only be done by government condemnation and purchase and that the operation and maintenance, including the agricultural aspects, of such a system could only be undertaken by a government agency. The effect is self-limiting in a number of ways. First of all, the enclave concept does not provide for the expansion of the area in any non-disruptive manner should the concept of recycling wastewater become general throughout the State of Ohio. Second, the concentration of such land for such single purpose would have the major effect of dislocation of a large number of homes and family farms, obviate the concept of supporting food production through the supply of nutrient materials to an increasing number of farms in the area, eliminate the idea and the cost saving factor of contracting with the private farms for the disposal of wastewater effluents and finally, cover one of the most significant archeological deposits in the State of Ohio, an area now known as the Willard Swamp.

It has been the policy in the United States to encourage the development and continuation of the family farm.. While this concept has not always been honored, the massive change in the farming patterns of the area and the probable reliance on a single, crop for the single purpose of wastewater treatment ignores the requirement for consideration of all areas of the greater environment and may have serious effects on the diversity and availability of local food

supply. In a period when the U.S. agricultural surplus has vanished, with serious doubts that it will even return; when the United Nations declares that there is no world food supply cushion and that all of us are dependent on current production; when agricultural products are the tools for reduction in our balance of payments deficit; and when they constitute a major factor in our foreign policy of "detente" with China and the Soviet Union, there must be a complete rethinking of the trade-offs involved between the economic factors and those indicated above.

If the concept of the necessity for long-range conservation of nutrient materials is coupled with the imperatives of national policy, the additional transmission costs necessary for servicing the current agricultural patterns may not seem so great; and a way will be formed for responding to any increase in demand for wastewater treatment on the land.

One final reiterative note must be made. Despite the array of solutions outlined for the management of wastewater in the Three Rivers Basin, it must not be assumed that all alternatives have been developed or that all management opportunities have been explored. For instance, in Attachment K an out-of-basin alternative is presented that describes the option of first reclaiming strip mined land and then using the land for indefinite effluent disposal. This approach obviates a number of negative factors in land use, institutional and social problems that bulk so large in other out-of-basin plans, and could be extended to promote new agricultural production.

As indicated elsewhere, the possibility that the design wastewater volumes are seriously overestimated, and that these in turn can lead to significant over capacity and costs well in excess of necessity, must be closely examined. For instance, the infiltration of ground water is a major source of large volumes of wastewater flow in sanitary and combined sewer systems. It may average more than 15% of the total flow and peak rates may double this. Under these conditions a separate sanitary sewer may even assume the flow characteristics of a combined sewer. Yet the condition is largely correctible using modern materials and careful workmanship. The potential for waste flow reduction and the hazards of wastewater projection are discussed in Attachment C, Analysis of Wastewater Projections.

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Attachment A

CHARACTERISTICS OF THE NORTH-CENTRAL OHIO AREA CONSIDERED FOR LAND TREATMENT TECHNOLOGY

1. Introduction

Among the wastewater treatment technologies considered for large scale use in the Cleveland-Akron metropolitan area was the land treatment process. This procedure uses secondary effluent to fertilize agricultural and wooded lands through a process of spray irrigation.

The volumes of effluent generated would exceed the capacity of suitable soils within the Three Rivers area if the land treatment process were to be used extensively. Consideration of these factors plus others--watershed agreements, low population density, suitable farm lands in close proximity--led to the designation of an area in North-Central Ohio as tentatively suitable for application of land treatment processes.

Certain characteristics of these out-of-basin agricultural areas were examined.

2. North Central Ohio - Agriculture

a. Physiography

The North Central Ohio area encompassing proposed land treatment sites for effluent disposal from the Three Rivers Watershed includes nine counties: Ashland, Crawford, Erie, Huron, Lorain, Richland, Sandusky, Seneca and Wyandot.

The area has three main river basins: Sandusky, Vermilion and Huron. The Sandusky River drains an area of 1,420 square miles, originating in Richland and Crawford Counties, flowing west to Upper Sandusky and then north to Sandusky Bay. The streams in the Huron and Vermilion Basins originate at the Lake Erie-Ohio River Divide and flow north in nearly parallel paths. The following data details the drainage areas and water yield from these basins:

Yield in Millions of Gallons (1) and MGD per Square Mile (2)

Basin	Drainage Area, sq.mi.	Min. yr. 1931		Average Year		Max. Yr. 1950	
		(1)	(2)	(1)	(2)	(1)	(2)
Sandusky	1,420	91,200	.176	245,000	.465	375,000	.724
Huron	406	28,200	.19	77,000	.465	115,000	.78
Vermilion	268	18,600	.19	57,000	.465	76,000	.78

(Source: Northwest Ohio Water Development Plan, Ohio Water Commission, Department of Natural Resources, October, 1967.)

Groundwater resources in the area are not of large quantity. Mississippian and Upper Devonian Rocks, primarily consisting of shale, cover a large portion of the area and produce little or no groundwater. Occasional sandstones provide minimal resources, and limestone deposits provide groundwater supplies which require conditioning treatment for hardness.

The physiography of the selected counties in North Central Ohio is defined within the Till and Lake Plains sections of the Central Lowlands province. The major portions of Lorain, Huron, Seneca, Crawford and Wyandot fall in the Till Plains Section, which is characterized by broken ridges. These end morain surface structures lying roughly parallel to the Lake Erie shoreline range several miles wide and 10-50 feet high and serve to control surface

drainage patterns. The Lake Plains section covers Erie, Sandusky, and parts of Seneca, Huron, and Lorain Counties, where a nearly flat to gently undulating topography is found. Characteristic features are the beach ridges composed of sand and gravel and shallow lake bottom silts and clays. Drainage is a problem in many parts of the Lake Plains, although much of the valuable agricultural soils can be successfully irrigated with supplemental drainage.

The area contains an abundance of rich agricultural soils High lime content, glacial age till soils appear in Wyandot, the main portion of Seneca and parts of Sandusky and Crawford Counties. Large areas in Crawford, Huron, Lorain, and parts of Erie and Richland Counties are overlaid with low lime glacial till soils where occasional spots of organic soils occur. Only the northern strips of Lorain and Huron and the greater portion of Erie County display poorly drained, low fertility, high acid soils. However, only a minimal portion of the rich agricultural soils found in the North Central counties are well-suited for irrigation. Even with supplemental drainage, about one-third of the soils are poorly suited for irrigation because of rapid ponding. In the remainder of the area, moderate adaptability requires supplemental drainage for successful irrigation.

Climate: The climate in Northwest Ohio can be described as moderate in precipitation, length of droughts, and temperature. The area is located in the north temperate zone, and its humid climate has warm summers and mildly cold winters. The mean annual temperature is a $51^{o}F$. The growing season averages about 170 days Precipitation and growing season data for the individual counties is presented in Table 1.

TABLE 1. Precipitation and Growing Season by County, 1970

County and Station	Inches/Annual Precipitation	Growing Season in Days
Ashland, Ashland	37.90	163
Ashtabula, Ashtabula	35.57	193
Crawford, Bucyrus	39.13	155
Erie, Sandusky	30.70	219
Huron, Norwalk	33.98	164
Lorain, Elyria	33.78	185
Richland, Mansfield	34.79	163
Sandusky, Fremont	34.99	162
Seneca, Tiffin	33.63	162
Wyandot, Upper Sandusky	32.97	188

Source: Ohio Almanac, 5th Edition, 1972

b. Land Use

The North Central Ohio counties proposed for land treatment sites are predominately characterized by agricultural land use, as is clearly indicated in Table 2. Although some reduction of land in farms can be found in several of the counties from 1954 to 1969 (Table 5), these decreases are relatively insignificant in contrast to Northeast Ohio. The Northwest Ohio Water Development Plan Report, in noting the rich agricultural soils abounding in the area, cautions that, "It is important that concerted attention be given to encouraging the continued use of the best of these soils for agricultural purposes. Wherever possible, zoning and industrial planning should be geared to this goal."

The area in general is not highly urbanized; the major urban centers of Northwest Ohio which serves these selected counties are Toledo (Lucas and Wood Counties), Lima (Allen County) and Lorain.

A brief summary of individual county characteristics will serve to indicate the general profile of each unit:

Ashland County. Located about 60 miles southwest of Cleveland, Ashland has a hilly rolling surface. The Savannah Lakes in the northern section and the Mohican and Jerome Fork river valleys in the southern section provide a productive sand-gravel loam soil. Ashland (19,872), the county seat and only city in the county, is the home of Ashland College.

Crawford County. Located about 60 miles north of Columbus, the county has rolling topography with numerous, scattered woodlots. The Sandusky River is the major physical feature of Crawford County and the entire reach has been cited by the State Department of Natural

Resources as a Recreational Resource. Bucyrus (13,111), the county seat, is the commercial center of the county.

Erie County. Generally sparse vegetation and flat topography characterizes the county, while the eastern portion has rolling topography and several large areas of tree cover. The Huron and Vermilion Rivers are the main physical features in the county and represent the most significant topographic variation; both have been cited by the Department of Natural Resources for recreation potential. Sandusky, the county seat, is the second largest coal-shipping port on the Great Lakes. Kelley's Island, in Lake Erie, is a popular recreation area with numerous facilities.

Huron County. Located about 50 miles southwest of Cleveland, the level surface is altered by a steeper topography found along the stream corridors, which are generally heavily wooded and offer scenic qualities. Wet timber areas as large as 500 acres are found in the county. Dominant physical features are the three north-south flowing rivers with narrow steep corridors and numerous tributaries (Vermilion River and the West Branch and East Branch of the Huron River). Norwalk (14,000), the largest city, is the county seat, although Bellevue (4,392), in the upper northwest corner, serves as a trade center for four counties.

Lorain County. Dominated by the Lorain-Elyria industrialized urban complex, the remainder of the county has rolling to steep topography along the river and stream corridors. Small woodlots are scattered throughout; the main physical features in the county are the east and west branches of the Black River, where topography is more rugged and tree cover is dense. Lorain, (city) is an important Lake Erie port and shipbuilding center.

Richland County. The northern half of the county is characterized by flat topography and scattered wood lots, while the southern portion has a rolling terrain with more tree cover. The Black Fork and Clear Fork of the Mohican River are dominant natural features, both of which have been recommended for recreational development in line with preserving the picturesque natural features prevalent there. Mansfield, the county seat and largest city, is located in the county's center; year-round recreation is a prominent Mansfield attraction.

Sandusky County. Located about 25 miles southwest of Toledo, Sandusky County exhibits a hilly terrain, but its fertile soil is easily cultivated. Major areas of vegetation occur along the stream and river corridors. Sandusky Bay and marshes dominate the northeast shoreline of the county, offering prime hunting and fishing areas. The north-flowing Sandusky River passes through the center of the county. A Scenic River designation by the State of Ohio has been made south from Fremont into adjacent Seneca and Wyandot Counties. Fremont (18,940), the county seat, is headquarters for a large beetsugar operation and maintains an extension of Bowling Green State University.

Seneca County. Rolling topography and scattered woodlots generally characterize Seneca County. Located about 40 miles southeast of Toledo, the surface is level and has a rich loam soil. Sandusky River is a fast stream through Seneca County, with about five miles of riffles and rapids north of Tiffin. Tiffin (21,596), the county seat, is a diversified industrial city and the location of Heidelberg College.

Table 2.

LAND USE CHARACTERISTICS -- WESTERN BASIN COUNTIES

COUNTY	Total Area	Urban	Non-Urban Total	Manu-facturing	Mining & Extract.	Commer-cial	Transp. & Utilities	Institu-tional	Recrea-tion	Water & Wet-lands	Agricul-ture & Other	Residen-tial
Ashland	272,640	4,800	267,840	40	400	--	3,870	1,770	5,140	1,680	251,700	3,240
		(1.8%)		(.01%)	(.15%)		(1.4%)	(0.65%)	(1.9%)	(.62%)	(92.0%)	(1.9%)
Crawford	258,560	5,810	252,750	120	170	50	3,150	130	--	130	246,300	2,660
		(2.2%)		(0.5%)	(.06%)	(.01%)	(1.2%)	(0.05%)	--	(.05%)	(95.0%)	(1.0%)
Erie	169,600	9,460	160,140	330	600	30	3,810	6,300	2,950	8,010	130,930	7,180
		(5.6%)		(.19%)	(.3 %)	(.02%)	(2.2%)	(3.7%)	(1.7%)	(4.7%)	(77.0%)	(4.2%)
Huron	318,080	5,160	312,920	--	270	--	3,860	40	1,770	2,510	298,970	5,500
		(1.6%)		--	(0.8%)	--	(1.2%)	(.01%)	(.6 %)	(.8 %)	(94.0%)	(1.7%)
Lorain	316,800	70,580	246,220	260	340	330	4,110	1,590	1,620	1,450	217,740	18,780
		(22.%)		(.08%)	(.1 %)	(.1 %)	(1.2%)	(.5 %)	(.51%)	(.49%)	(68.7%)	(5.9%)
Richland	319,360	15,010	302,350	320	180	20	5,370	2,890	310	2,390	282,210	10,660
		(4.7%)		(.1 %)	(.05%)	(.006%)	(1.7%)	(.9 %)	(.09%)	(.7 %)	(88 %)	(3.3%)
Seneca	352,640	5,030	347,610	60	760	20	4,250	210	110	720	337,260	4,120
		(1.4%)		(.02%)	(.2 %)	(.006%)	(1.2%)	(.06%)	(.03%)	(.2 %)	(96 %)	(1.2%)
Sandusky	266,240	4,830	261,410	--	1,070	100	4,080	40	240	7,060	242,240	6,580
		(1.8%)			(.4 %)	(.04 %)	(1.5%)	(.01%)	(.09%)	(2.6%)	(91 %)	(2.5%)
Wyandot	259,840	1,910	257,930	10	500	20	2,920	40	6,560	480	245,640	1,760
		(0.07%)		(.004%)	(.19%)	(.008%)	(1.1%)	(.01%)	(2.5%)	(.2 %)	(94.5%)	(.7%)
TOTAL OHIO	26,381,670	11,388,870	25,242,800	22,450	194,950	7,130	298,040	158,270	439,310	220,100	23,198,530	704,380

Source: Ohio Department of Development, Planning Division, 1960 Detailed Land Use Plan.

Wyandot County. Rural character similar to the other counties in the region is exhibited. The Sandusky River corridor is the major physical feature in the county, with tree cover and topographic contrast along this corridor providing scenic diversity to the county's level surface. No cities are located in Wyandot; Upper Sandusky Village (5,645) is the county seat and largest village in this low-density area.

c. Demography and Economic Activity

The selected counties cannot be viewed as a self-sufficient region; rather, they are a relatively less-populated, low-density, and under-industrialized group compared to the State as a whole and to the Northwest Ohio urban centers of Toledo, Lima and Lorain However, a healthy population growth has been exhibited during the century, as indicated in Table 3. Projected population expansion is expected to occur predominately adjacent to the major urban centers Employment projections for the Northwest Ohio region as a whole anticipate a potential for the continued, long-term average growth of 1.6 percent per year, based on the criteria of the area's market accessibility combined with the existing labor supply and industry structure.

Although agricultural activity dominates the general character of these North Central counties, the economic base is relatively diversified. Table 4 presents the industrial composition for 1960 and 1970, from which increases in the manufacturing sector for all counties during the past decade can be readily noted The proportionate distribution of manufacturing activities comprising that growth indicates a rather diverse range of endeavors, although

TABLE 3 Population Growth by County: 1900-1970 (North-Central Ohio Counties)

County	1900	1910	1920	1930	1940	1950	1960	1970
Ashland	21,184	22,975	24,627	26,867	29,785	33,040	38,771	43,303
Crawford	33,915	34,036	36,054	35,345	35,571	38,738	46,775	50,364
Erie	37,650	38,327	39,739	42,133	43,201	56,565	68,000	75,909
Huron	32,330	34,206	32,424	33,700	34,800	39,353	47,326	49,587
Lorain	54,857	76,037	90,612	109,206	112,390	148,162	217,500	256,843
Richland	44,289	47,667	55,278	65,902	73,853	91,305	117,761	129,997
Sandusky	34,311	35,171	37,109	39,731	41,014	46,114	56,486	60,983
Seneca	41,163	42,421	43,176	47,941	48,499	52,978	59,326	60,696
Wyandot	21,125	20,760	19,481	19,036	19,218	19,785	21,648	21,826
OHIO	4,157,545	4,767,121	5,759,394	6,646,697	6,907,612	7,946,627	9,706,392	10,650,903

Sources: 1900-1960 - Statistical Abstract of Ohio, 1969, Economic Research Division, Department of Development, State of Ohio.

1970 - 1970 Census of Population, Final Population Counts, Ohio PC(VI)-37 Bureau of the Census, U.S. Department of Commerce.

TABLE 4 INDUSTRIAL COMPOSITION OF COUNTIES WITH POTENTIAL LAND DISPOSAL SITES: 1960 & 1970

Industry	ASHLAND COUNTY 1960	(%)	1970	(%)	CRAWFORD COUNTY 1960	(%)	1970	(%)	ERIE COUNTY 1960	(%)	1970	(%)
Industry	14,798	100%	17,522	100%	17,827	100%	19,817	100%	23,665	100%	28,834	100%
Agric., Forestry & Fisheries	1,385	9.3	1,708	6.1	1,504	8.4	783	3.9	1,134	4.8	570	1.9
Mining	75	0.5	76	0.4	44	0.2	46	2.3	129	0.5	107	0.4
Construction	960	6.5	971	6.6	749	4.2	682	3.4	1,399	5.9	1,476	[illegible]
Manufacturing	5,802	39.2	7,316	41.7	7,778	43.6	9,640	48.6	8,799	37.2	11,438	[illegible]
Furniture & Lumb. & Wood Prod.'s	68	0.5	68	0.4	41	0.2	71	0.4	129	0.5	188	0.6
Metal Industries	797	5.3	777	4.4	644	3.6	761	3.8	1,626	6.9	1,867	6.5
Mach. exc. Elec.	915	6.2	1,254	7.2	2,118	11.9	2,712	13.7	1,824	7.7	2,776	9.6
Elec. Machinery Equip. & Sy's	327	2.2	432	2.4	1,921	10.7	1,977	10.1	590	2.5	236	0.8
Transportation Equip. (Inc. Mtr. Vehicles)	585	3.9	772	4.1	835	4.7	1,245	6.2	1,462	6.2	2,840	9.8
Other Durables	598	4.0	897	5.1	401	2.2	949	4.8	590	2.5	916	3.2
Food & Kindreds	267	1.8	215	1.2	234	1.3	136	0.7	774	3.3	641	2.2
Textiles & Fabr.'d Textile Prod.'s	175	1.2	249	1.4	398	2.2	70	0.3	66	0.3	44	0.2
Printing, Publish. & Allied Prod.'s	619	4.2	440	2.5	226	1.3	265	1.3	396	1.7	279	1.0
Chemical & Allied Products	177	1.2	207	1.2	20	0.1	31	0.2	133	0.6	175	0.6
Other Non-Durables (Incl. Not Spec. Mfg.)	1,274	8.6	2,005	11.4	940	5.3	1,423	7.2	1,219	5.1	2,476	5.1
Railroad & R.R. Express Svc.	70	0.5	65	0.4	793	4.4	312	1.6	486	2.0	358	1.2
Trucking Svc. & Warehousing	206	1.4	184	1.0	159	0.9	212	1.1	528	2.2	479	1.7
Other Transport.	73	0.5	61	0.3	29	0.2	92	0.5	450	1.9	249	0.9
Communications	138	0.9	193	1.1	78	0.4	216	1.1	184	0.7	214	0.7

Table 4 (con't)

	ASHLAND COUNTY				CRAWFORD COUNTY				ERIE COUNTY			
	1960	(%)	1970	(%)	1960	(%)	1970	(%)	1960	(%)	1970	(%)
Utilities & Sanitary Service	178	1.2	233	1.3	171	0.9	238	1.2	299	1.3	568	0.[illegible]
Wholesale Trade	181	1.2	307	1.7	398	2.2	320	1.6	556	2.3	871	3.[illegible]
Food & Dairy Product Stores	424	2.9	401	2.3	407	2.3	355	1.8	559	2.4	593	2.[illegible]
Eating & Drinking Places	370	2.5	489	2.8	587	3.3	633	3.1	805	3.4	1,012	3.5
Other Retail Trade	1,231	8.3	1,506	8.6	1,471	8.2	1,800	9.0	2,202	0.8	2,811	9.7
Finance, Insurance & Real Estate	347	2.3	462	2.6	406	2.3	457	2.3	593	2.5	874	3.0
Business & Repair Services	134	0.9	278	1.6	247	1.4	286	1.4	389	1.6	482	1.7
Private Households	359	2.4	137	0.8	334	1.9	287	1.4	443	1.9	235	0.8
Other Personal Svcs.	332	2.2	351	2.0	336	1.9	461	2.3	506	2.1	775	2.7
Entertainment & Recreation Svcs.	66	0.4	82	0.5	100	0.6	82	0.4	192	0.8	427	1.5
Hospitals	236	1.6	356	2.0	266	1.5	503	2.5	571	2.4	1,209	4.1
Health Services			293	1.7			392	2.0			572	2.0
Educational Svcs.	862	5.8	1,817	10.4	706	3.9	1,086	5.5	1,061	4.5	1,670	5.8
Welf., Relig. & Non-Profit Memb. Org.'s.	194	1.3	170	1.0	206	1.1	200	1.0	[illegible]	1.1	278	0.9
Other Professional & Related Services	259	1.7	323	1.8	246	1.4	217	1.1	537	2.3	422	1.4
Public Administration	388	2.6	373	2.1	503	2.8	517	2.6	593	2.5	1,144	4.0

Table 4 (con't)

Industry	HURON COUNTY 1960	(%)	1970	(%)	LORAIN COUNTY 1960	(%)	1970	(%)	RICHLAND COUNTY 1960	(%)	1970	(%)
	16,726	100%	18,696	100%	75,758	100%	95,385	100%	43,194	100%	50,945	100%
Agric., Forestry & Fisheries	1,619	9.7	963	5.1	2,222	2.9	1,761	1.8	1,322	3.1	943	1.8
Mining	35	0.2	45	0.2	404	0.5	161	0.2	54	0.1	55	0.1
Construction	984	5.9	1,101	5.8	3,501	4.6	4,478	4.7	2,053	4.7	2,288	4.5
<u>Manufacturing</u>	4,890	29.2	7,196	38.5	34,331	45.3	40,800	42.8	19,033	44.1	22,248	43.7
Furniture & Lumb. & Wood Prod.'s	287	1.7	353	1.9	106	0.14	152	0.5	335	0.8	253	0.5
Metal Industries	530	3.2	755	4.0	15,359	20.2	15,331	16.0	4,152	9.6	5,533	10.8
Mach. exc. Elec.	538	3.2	962	5.1	2,334	3.1	3,332	3.5	1,070	2.5	1,744	3.4
Elec. Machinery Equip. & Sy's	343	2.0	478	2.5	1,307	1.7	1,667	1.7	5,995	13.9	6,575	12.9
Transportation Equip. (Inc. Mtr. Vehicles)	592	3.5	1,021	5.5	9,711	12.8	11,866	12.4	2,023	4.7	1,453	2.8
Other Durables	421	2.5	554	3.0	1,064	1.4	2,750	2.9	1,553	3.6	2,797	5.5
Food & Kindreds	380	2.3	347	1.8	777	1.0	530	0.6	602	1.4	216	0.4
Textiles & Fabr.'d Textile Prod.'s	441	2.6	298	1.6	183	0.2	426	0.4	166	0.4	197	0.4
Printing, Publish. & Allied Prod.'s	556	3.3	939	5.0	1,257	1.6	1,229	1.3	883	2.0	1,082	2.1
Chemical & Allied Products	35	0.2	101	0.6	1,520	2.0	1,926	2.0	66	0.15	77	0.15
Other Non-Durables (Incl. Not Spec. Mfg.)	767	4.6	1,388	7.4	713	0.9	1,591	1.7	2,158	5.0	2,321	4.6
Railroad & R.R. Express Svc.	1,389	8.3	1,117	5.9	1,172	1.5	861	0.9	349	0.8	171	3.3
Trucking Svc. & Warehousing	754	4.5	511	2.7	1,202	1.6	1,027	1.0	677	1.6	971	1.9
Other Transport.	94	0.6	101	0.5	378	1.2	906	0.9	185	0.4	179	0.35
Communications	196	1.2	213	1.1	652	0.9	1,022	1.0	259	0.6	850	1.7

Table 4 (con't)

	HURON COUNTY				LORAIN COUNTY				RICHLAND COUNTY			
	1960	(%)	1970	(%)	1960	(%)	1970	(%)	1960	(%)	1970	(%)
Utilities & Sanitary Service	143	0.8	343	1.8	1,202	1.6	1,656	1.7	476	1.1	433	
Wholesale Trade	291	1.7	487	2.6	1,164	1.6	2,083	2.2	1,163	2.7	1,665	[illegible]
Food & Dairy Product Stores	434	2.6	394	2.1	1,954	2.6	2,532	2.6	1,042	2.4	1,082	2.1
Eating & Drinking Places	518	3.1	489	2.6	2,308	3.0	2,803	2.9	1,245	2.9	1,689	3.3
Other Retail Trade	1,464	8.7	1,356	7.2	6,314	8.3	8,885	9.3	3,829	8.9	4,784	9.4
Finance, Insurance & Real Estate	337	2.0	454	2.4	2,023	2.7	2,680	2.8	1,464	3.4	2,035	3.9
Business & Repair Services	250	1.5	308	1.6	1,224	1.6	2,310	2.4	715	1.6	1,222	2.4
Private Households	356	2.1	166	0.9	1,229	1.6	668	0.7	884	2.0	484	0.95
Other Personal Svcs.	318	1.9	416	2.2	1,626	2.2	2,143	2.2	1,136	2.6	1,408	2.7
Entertainment & Recreation Svcs.	94	0.6	48	0.3	491	0.7	665	0.7	186	0.4	297	0.6
Hospitals	281	1.7	380	2.0	1,553	2.1	2,996	3.1	838	1.9	1,315	2.6
Health Services			370	1.9			1,902	1.9			906	1.8
Educational Svcs.	791	4.7	1,179	6.3	3,721	4.9	7,126	7.5	1,668	3.9	2,919	5.7
Welf., Relig. & Non-Profit Memb. Org.'s.	159	0.9	161	0.8	834	1.1	1,310	1.4	503	1.2	643	1.2
Other Professional & Related Services	327	1.9	279	1.5	1,437	1.9	1,527	1.6	819	1.9	667	1.3
Public Administration	582	3.5	619	3.3	1,764	2.3	3,083	3.2	1,613	3.7	1,691	3.3

Table 4 (con't)

Industry	Sandusky County 1960	(%)	Sandusky County 1970	(%)	Seneca County 1960	(%)	Seneca County 1970	(%)	Wyandot County 1960	(%)	Wyandot County 1970	(%)
Industry	19,862	100%	22,419	100%	20,557	100%	22,424	100%	7,638	100%	8,153	100%
Agric., Forestry & Fisheries	1,684	8.5	840	3.7	1,834	8.9	1,060	4.7	1,351	17.7	599	7.8
Mining	101	0.5	89	0.4	130	0.6	106	0.5	123	1.6	197	2.4
Construction	1,006	5.0	1,373	6.1	882	4.3	940	4.2	386	5.0	551	6.5
Manufacturing	7,006	35.2	9,315	41.5	8,103	39.4	9,428	42.0	2,366	31.0	3,[illegible]	37.0
Furniture & Lumb. & Wood Prod.'s	56	0.3	192	0.8	262	1.2	173	0.7	90	1.2	[illegible]	0.5
Metal Industries	1,571	7.9	1,247	5.6	884	4.3	740	3.3	117	1.5	211	2.6
Mach. exc. Elec.	329	1.6	658	2.9	1,373	6.6	2,057	9.2	397	5.2	443	5.5
Elec. Machinery Equip. & Sy's	1,661	8.4	2,624	11.7	2,595	12.6	3,129	13.9	411	5.4	848	10.4
Transportation Equip. (Inc. Mtr. Vehicles)	429	2.1	1,155	5.1	257	1.2	593	2.6	145	1.9	178	2.2
Other Durables	1,036	5.2	972	4.3	1,552	7.5	1,701	7.6	457	6.0	378	4.6
Food & Kindreds	826	4.1	1,021	4.5	392	1.9	264	1.1	148		130	1.6
Textiles & Fabr.'d Textile Prod.'s	472	2.4	313	1.4	36	0.2	20	0.1			9	0.1
Printing, Publish. & Allied Prod.'s	207	1.0	303	1.3	389	1.9	366	1.6	45	0.6	52	0.6
Chemical & Allied Products	88	0.4	90	0.4	122	0.6	54	0.2	37	0.5	12	0.2
Other Non-Durables (Incl. Not Spec. Mfg.)	331	1.6	740	3.3	241	1.2	331	1.5	519	6.8	706	8.6
Railroad & R.R. Express Svc.	463	2.3	467	2.1	393	1.9	268	1.2	143	1.9	113	1.4
Trucking Svc. & Warehousing	227	1.1	449	2.0	455	2.2	387	1.7	97	1.3	173	2.1
Other Transport.	88	0.4	134	0.6	71	0.3	86	0.4	3	0.04	21	0.2
Communications	136	0.7	208	0.9	148	0.7	115	0.5	71	0.9	74	0.9

Table [illegible] (con't)

	SANDUSKY COUNTY				SENECA COUNTY				WYANDOT COUNTY			
	1960	(%)	1970	(%)	1960	(%)	1970	(%)	1960	(%)	1970	(%)
Utilities & Sanitary Service	244	1.2	232	1.0	209	1.0	304	1.3	64	0.8	108	1.3
Wholesale Trade	327	1.6	416	1.8	400	1.9	507	2.3	150	1.9	170	2.0
Food & Dairy Product Stores	647	3.2	556	2.5	456	2.2	454	2.0	194	2.5	125	2.1
Eating & Drinking Places	720	3.6	707	3.1	467	2.2	744	3.3	274	3.6	252	3.1
Other Retail Trade	1,707	8.6	2,264	10.1	1,775	8.6	2,109	9.4	654	8.6	783	9.6
Finance, Insurance & Real Estate	389	1.9	534	2.4	356	1.7	511	2.3	131	1.7	128	1.6
Business & Repair Services	388	1.9	376	1.7	300	1.4	306	1.3	97	1.3	158	1.9
Private Households	382	1.9	188	1.8	509	2.4	267	1.2	150	1.9	138	1.7
Other Personal Svcs.	384	1.9	600	2.7	410	1.9	519	2.3	229	2.9	226	2.7
Entertainment & Recreation Svcs.	93	0.5	190	0.8	145	0.7	126	0.5	66	0.9	13	0.6
Hospitals	411	2.1	528	2.3	688	3.3	928	4.1	108	1.4	130	1.6
Health Services			409	1.8			584	2.6			257	3.1
Educational Svcs.	769	3.9	1,388	6.2	1,179	5.7	1,547	6.9	354	4.6	400	4.9
Welf., Relig. & Non-Profit Memb. Org.'s.	284	1.4	288	1.3	380	1.8	338	1.5	175	2.3	79	1.0
Other Professional & Related Services	438	2.2	226	1.0	326	1.6	258	1.1	87	1.1	157	1.9
Public Administration	670	3.3	642	2.9	435	2.1	532	2.4	208	2.8	283	3.5

Source: U.S. Bureau of the Census, General Social and Economic Characteristics, OHIO PC (1)-37C, 1960 Table 85. U.S. Bureau of the Census, 1970, PC (1) C37, Table 123.

a relatively significant concentration appears in "Metal Industries," "Machinery" and "Electrical Machinery Equip. & Sy." for most counties

d. Agricultural Activity

The decrease in agricultural employment observed from 1960 and 1970 (Table 4) is not paralleled by an equally significant decrease in agricultural productivity and market value. Advanced farming practices have relieved manpower requirements substantially, and the total land in farms has not changed appreciably in the past two decades.

Tables 5, 6, and 7 present data on farm land uses, agricultural output, production value, and the ranked order of important farm commodities for the selected counties. It may be noted that these North Central Ohio counties under consideration as land treatment sites for wastewater management indicate a trend toward fewer farms of larger acreage, similar to the agricultural land use changes with the Three Rivers Basin. However, the proportion of those North Central Ohio counties in agricultural land shows insignificant decreases and, in some cases, minor increases, thus retaining the substantial rural character of the areas involved.

The distribution of major agricultural commodities relative to cash receipts from farm marketings varied somewhat among these North Central Ohio counties. However, dairy products, soybeans, vegetables, and cattle were of relatively significant importance throughout most of the area. In terms of total state cash receipts from major agricultural commodities, Ashland was among the top ten dairy producers in 1970, Sandusky was the tenth highest soybean producer, Seneca ranked fourth in wheat output and Huron, Sandusky and Erie were leading vegetable producers.

TABLE 5. Trends in Agricultural Land Use, 1954, 1959, 1964, & 1969.

	Farms (Number)				Average Size of Farm (Acres)			
	1954	1959	1964	1969	1954	1959	1964	1969
OHIO TOTAL	177,074	140,353	120,381	111,332	112.9	131.9	146.4	153.6
Counties with Potential Land Treatment Sites:								
Ashland	2,048	1,676	1,471	1,476	113.0	127.8	140.9	139.0
Crawford	1,746	1,555	1,349	1,504	132.7	151.0	168.2	158.0
Erie	1,151	832	698	702	106.3	137.0	156.2	152.0
Huron	2,018	1,758	1,582	1,557	138.2	154.3	171.4	178.7
Richland	2,394	1,769	1,537	1,475	106.2	122.0	132.0	135.4
Sandusky	1,953	1,743	1,509	1,488	118.2	134.2	154.7	161.9
Seneca	2,288	2,115	1,821	1,887	142.4	153.7	176.2	174.7
Wyandot	1,537	1,266	1,149	1,196	160.1	189.3	213.6	202.2

	Land in Farms (Acres)				Proportion of All Land Area in Farms			
	1954	1959	1964	1969	1954	1959	1964	1969
OHIO TOTAL	19,991,586	18,506,796	17,619,167	17,111,459	76.2%	70.6%	67.2%	65.2%
Counties with Potential Land Treatment Sites:								
Ashland	231,503	214,151	207,329	205,225	86.5	80.1	77.5	75.7
Crawford	231,712	234,868	226,945	237,730	89.6	90.8	87.8	91.9
Erie	122,336	114,018	109,050	106,733	72.4	67.5	64.5	63.2
Huron	278,934	271,221	271,165	278,241	87.7	85.3	85.2	87.5
Richland	254,291	215,858	202,835	199,717	79.9	67.9	63.8	63.0
Sandusky	230,916	233,981	233,405	240,924	88.0	89.2	88.9	92.0
Seneca	325,708	324,897	320,865	329.755	92.4	92.2	91.0	93.5
Wyandot	246,089	239.651	245,475	241,872	94.7	92.2	94.4	93.1

Source: U.S. Dept. of Commerce, Bureau of the Census, Census of Agriculture, 1954, 1959, 1964, 1969.

TABLE 6. Cash Receipts from Farm Marketings, and the Rank of the Eight Major Commodities by Relative Importance, Counties with Potential Land Treatment Sites, 1970 and 1962.

County	Total Cash Receipts	EIGHT MAJOR COMMODITIES & PERCENTAGE OF TOTAL CASH RECEIPTS FROM SALES							
		RANK I	RANK 2	RANK 3	RANK 4	RANK 5	RANK 6	RANK 7	RANK 8
Ashland									
1970	$15,238	Dairy 51	Cattle 17	Hogs 8	Poultry 7	Corn 4	Wheat 3	Soybns 3	Hay 2
1962	11,383	Dairy 43	Cattle 16	Hogs 11	Poultry 7	Wheat 7	Corn 3	Soybns 3	Sheep 2
Crawford									
1970	17,403	Hogs 21	Soybns 20	Cattle 19	Corn 12	Dairy 11	Wheat 5	Poultry 4	Oth Lvestk 3
1962	13,078	Hogs 24	Dairy 15	Cattle 15	Soybns 15	Wheat 10	Corn 7	Poultry 6	Sheep 4
Erie									
1970	10,668	Vegs 20	Dairy 18	Soybns 15	Corn 12	Cattle 7	Fruit 6	Hogs 5	Poultry 4
1962	8,399	Vegs 19	Dairy 17	Soybns 13	Corn 11	Cattle 10	Wheat 10	Hogs 6	Fruits 6
Huron									
1970	20,338	Vegs 22	Soybns 20	Dairy 13	Corn 12	Cattle 10	Hogs 8	Wheat 5	Poultry 4
1962	15,495	Soybns 16	Dairy 18	Vegs 14	Cattle 12	Corn 9	Wheat 9	Hogs 9	Poultry 6
Richland									
1970	11,773	Dairy 26	Soybns 15	Cattle 15	Hogs 10	Corn 8	Poultry 7	Grh&Nurs 5	Wheat 5
1962	9,057	Dairy 25	Hogs 12	Soybns 10	Cattle 10	Poultry 9	Wheat 8	Grh&Nurs 6	Corn 6
Sandusky									
1970	23,122	Soybns 22	Vegs 14	Cattle 12	Dairy 10	Corn 10	SugBts 1	Hogs 7	Wheat 4
1962	17,563	Cattle 19	Dairy 16	Soybns 14	Corn 10	Wheat 9	Hogs 7	Vegs 7	SugBts 5
Seneca									
1970	21,543	Soybns 23	Dairy 16	Corn 14	Hogs 13	Cattle 12	Wheat 6	Poultry 4	Vegs 3
1962	17,857	Soybns 17	Dairy 17	Hogs 13	Corn 12	Cattle 12	Wheat 11	Poultry 6	Sheep 2
Wyandot									
1970	17,072	Soybns 27	Hogs 19	Corn 18	Cattle 11	Dairy 9	Wheat 6	Poultry 5	Sheep, Lambs2
1962	13,456	Hogs 20	Soybns 20	Corn 14	Dairy 11	Wheat 10	Cattle 9	Poultry 7	Sheep 4

Source: Ohio Farm Income, 1962 and 1970, Agricultural Research & Development Center, Wooster, Ohio,

TABLE 7. Selected Agricultural Characteristics: Counties with Potential Land Treatment Sites

	Ashland	Crawford	Erie	Huron	Lorain	Richland	Sandusky	Seneca	Wyandot
Land in farms (acres)	205,255	237,730	106,733	278,241	161,091	199,717	240,924	329,755	241,872
% of county	75%	92%	63%	87%	51%	62%	90%	93%	94%
Average size of farm	139.0	158.0	152.0	178.7	119.5	135.4	161.9	174.7	202.2
Average value per acre (Land & buildings)	$319	$381	$593	$319	$608	$337	$543	$406	$411
Farm land uses (acres)									
Total cropland	141,178	194,601	87,830	212,616	126,202	140,423	208,239	271,501	201,700
Harvested cropland	89,054	149,378	64,461	158,727	84,116	87,848	160,598	207,941	153,947
Woodland including woodland pasture	34,263	23,233	7,869	37,339	19,357	30,391	13,852	31,816	20,108
Irrigated land	463	73	207	1,612	799	272	566	112	17
Farm production value									
Market value of all agricultural products sold	$14,307,595	$17,606,465	$9,021,154	$17,828,404	$17,078,365	$12,078,971	$5,262,403	$20,872,852	$15,556,759
Value of crops including nursery products & hay sold	$2,051,710	$6,714,844	$4,863,292	$10,745,308	$10,107,591	$3,380,721	$13,187,266	$11,562,345	$8,643,266
Value of livestock, poultry & their products sold	$12,140,704	$10,863,175	$4,143,164	$7,023,631	$6,953,590	$8,579,858	$8,020,122	$9,276,912	$6,886,209
Livestock & Poultry									
Cattle & calves-tot.	35,953	21,431	8,212	15,216	16,865	21,209	18,801	19,552	13,145
Sales	$18,167	$16,564	$4,698	$10,440	$8,651	$16,200	$13,431	$11,665	$9,221
Milk cows on place	11,293	3,141	2,915	4,228	7,566	4,523	3,973	5,818	2,321
Hogs & Pigs	18,170	51,297	7,108	25,242	7,758	20,136	21,959	38,744	33,848
Sales	$28,827	$83,148	$13,413	$39,275	$10,076	$30,173	$32,916	$59,007	$56,010
Sheep & Lambs	13,192	24,986	2,489	16,114	5,063	12,317	6,465	22,911	22,015
Sales	$9,546	$18,567	$1,788	$11,455	$3,907	$8,096	$5,867	$15,014	$16,774
Chickens 3 mos. or more	127,732	122,295	71,477	59,474	80,753	100,522	137,632	106,832	113,338
Boilers & oth. meat-type chickens less than 3 mos. old (sales)	34,963	---	15	36	1,801	21	402	196	---

TABLE 7 (cont.) Selected Agricultural Characteristics: Counties with Potential Land Treatment Sites

	Ashland	Crawford	Erie	Huron	Lorain	Richland	Sandusky	Seneca	Wyandot
Crops Harvested (acres)									
Field corn for all purposes	31,312	51,604	19,851	43,501	20,763	25,342	47,312	60,449	48,618
Wheat for grain	10,433	20,883	10,810	22,253	9,895	11,798	20,595	31,221	22,675
Soybeans	5,583	52,833	17,174	63,816	25,243	20,633	54,651	81,916	61,243
Hay (excluding sorghum hay)	29,425	12,491	5,130	12,236	17,973	18,346	12,423	16,685	9,763
Alfalfa & alfalfa mixtures for hay or dehydrating	9,868	3,457	3,271	4,237	6,420	5,006	429	7,231	3,016
Irish potatoes & sweet potatoes	64	1	114	410	479	242	357	181	--
Vegetables, sweet corn or melons for sale	120	13	3,946	3,502	1,555	311	7,254	1,694	374
Berries	20	5	28	20	40	41	46	16	8
Land in orchards	182	46	1,305	374	1,360	831	1,409	24	138
Greenhouse products under glass or other protection (sq. ft.)	46,392	--	645,000	35,500	6,588,802	56,880	86,840	111,600	--

Source: U.S. Census of Agriculture, 1969.

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Attachment B

CHARACTERISTICS OF THE EASTERN OHIO STRIPMINED AREAS CONSIDERED FOR TREATMENT

1. Introduction

The wastewater treatment system proposed for the Three Rivers Basin will extract some 500 to 900 dry tons of sludge per day, depending on the level of treatment required and the specific biological treatment. The stabilized sludge will contain high amounts of organic matter and substantial percentages of phosphorus and organic nitrogen. While of lesser strength than chemical fertilizers, the product is equal to animal manures and has excellent soil conditioning properties. The tonnage represents not only a major disposal problem but also a valuable resource that must be reused. A significant opportunity for that reuse exists in the ravaged stripmined areas of eastern and southeastern Ohio.

The importance of these twenty-eight counties, constituting the Ohio portion of Appalachia, lies in the negative values established by uncontrolled strip mining activity that has vandalized hundreds of thousands of acres--and, in the consequent need for reclamation of that land for some future productive use and esthet quality. These counties share many of the basic problems and characteristics of Appalachia and for this reason it is useful to look at the entire area and the conditions that demand a major rehabilitative effort; an effort that will mutually benefit the disposal of urban sludges and the raw land.

2. Appalachia

The Appalachia of today is an area of ancient mountains, now better known as an economically depressed, geographic area that reaches in an irregular band through parts of a dozen states from New York to Alabama. The reasons advanced for the regional depression are complex, but blame has been placed on such diverse problems as lack of communications, health care or education, poor diet and housing, or on the physical damages caused by overcutting timber, soil erosion and stream sedimentation in concert with absentee ownership of surface and mineral rights in the land. Certainly much of the distress came from changes in the economy of the region due to rapid mechanization of coal mining, the decline in farm employment, and various shifts in both markets and technology. For example, between 1950 and 1960, railroad employment dropped 40% as a result of a shift to highway transport and the replacement of coal-fired engines with diesel.

Appalachia historically has possessed a dangerously specialized economy, heavily dependent upon the exploitation of the region's abundant natural resources, primarily of coal. Twenty-five years ago, 10% of Appalachia's labor force, nearly a half million men, worked in the coal mines. During the 1950's, however, new technologies were developed which made it possible to mine more coal with far fewer men, and for other fuels--oil, gas, and nuclear power--to capture many of the markets once served by coal. The demand for coal has returned with the insatiable demand for additional electrical power. But the employment has not returned. Mining techniques have changed. It has become a simple matter to

reach and remove a seam of coal with a dozen men instead of hundreds. Automation has made the miner jobless, and at the same time, has turned a portion of his homeland into an unmitigated ecological disaster.

The Appalachian bituminous coal basin is 800 miles long, extending from northern Pennsylvania to western Alabama. It attains its greatest width of 175 miles in Pennsylvania and Ohio, and is only 35 miles wide at its narrowest point in Tennessee. While most coal is still mined in underground operations, the percentage of strip mining is steadily increasing. In 1964, some 20% of coal was extracted by strip mining, a figure that had risen to over 33% by 1970 and is now estimated at about 50%. Over a million acres in Appalachia have been "disturbed," a euphemism for the destruction perpetrated, and of these, some 276,000 acres were in Ohio as of 1964.

A 1966 report by the Secretary of the Interior stated that "the large tracts of unreclaimed land existing today have resulted essentially from past failure to recognize reclamation as a necessary part of the cost of mining...society through ignorance or apathy accepted the alternatives--erosion, acid drainage, lowered water quality and other detrimental after effects--as costs of "progress." It is soberly realized that some of the past benefits of the "progress" involve deferred costs for which payments have come due." This simplistic appraisal ignored the long history of battles against the strippers who received the benefits, but acknowledged the deferred social costs which are still being accumulated!

Like so many other problems in the control of pollution, those generated by strip mining are complex and highly pervasive. While the addition of sludges to the stripmined land will replace some of the organic material buried under spoil, the land will require major pre-forming and extended management. It is extremely doubtful that all land will be capable of rehabilitation. A review of the nature of strip mining, how it is carried out, and the conditions that it causes will indicate certain characteristics of the Ohio counties selected and the problems of reclamation.

3. Strip Mining

Strip mining is essentially what the name implies, a stripping of the cover of "overburden" over the coal, be it forest, top soil, or layers of subsoil and rock strata. Technological advances manifested by mammoth shovels and bulldozers are making it possible to move larger and larger amounts of overburden to reach underlying coal. Furthermore, in thermal generation of electricity, the most important use of coal today, the lower quality coal generally produced by strip mining can be burned as efficiently as the more expensive, higher quality coal produced at underground mines. The TVA, for instance, once a world-wide example of conservation, is the largest buyer of stripmined coal, using over 40,000 tons each day.

There are several surface mining techniques used to meet some particular set of conditions. They are usually referred to as open pit mining, area and contour strip mining, auger mining, dredging and hydraulicking. Of these, the strip and auger methods are the worst environmental offenders, and are used for coal in

contrast to other methods used for quarrying and metal extraction. Such mining methods as the open pit seldom arouse the opposition the strip miners face since they disturb relatively smaller areas and provide work longer. They may last half a century or more, whereas with coal seams averaging only a few feet thick, strippers move rapidly over large areas. Secretary of the Interior Udall, writing in "Surface Mining and the Environment," said "it is accepted practice to mine as cheaply as possible the deposits that are most accessible and provide the greatest profit to the producer. This preoccupation with short term gain too frequently has ignored the long term social costs involved--the silted streams, the acid-laden waters, and the wasteland left by surface mining."

Area stripping is usually carried out on relatively flat terrain. A cut is made through the over burden to expose the seam, after which the coal is blasted and dug out. The first cut is extended either to the limits of the property or the deposit, with the spoil bank forming a long ridge paralleling the first cut. As each succeeding parallel cut is made, the spoil or overburden is deposited in the cut previously excavated. The final cut leaves an open trench equal in depth to the thickness of the overburden and the coal bed recovered, bounded on one side by the last spoil bank, and on the other, by the undisturbed high wall. The resulting terrain, unless graded or leveled, resembles the ridges of a gigantic washboard. The ridges have crests 50 or more feet high, 50 to 100 feet apart, and with slopes between 17 and 39 degrees. While the rate of erosion is comparable to that associated with contour stripping, some of the sediment is retained in depressions on the site.

Where horizontal beds of coal are found in hilly or mountainous country, contour stripping is the most common practice. This method removes the overburden from the bed, starting where it outcrops on the hill and proceeding around the hillside in a ribbonlike operation. Successive cuts into the hillside are made until the overburden becomes too thick to remove profitably. This type of mining creates a shelf or "bench." On the inside, it is bordered by the high wall, ranging in height from a few to more than a hundred feet On the outside are steep slopes composed of the "spoil" material that has been cut out of the mountain.

It is estimated that 75% of the strip mining in Appalachia is contour mining, largely conducted on slopes exceeding 11%. In the 1966 report, over 18,000 miles of strip mine contours already existed, affecting about 30 acres per linear mile. Along 5000 miles, spoil had been pushed totally off the minebench, to cascade downslope, eventually into Appalachian streams. On the remaining 13,000 miles, the spoil is partially stacked along the out edge where its potential for landslides is extreme. The loose spoil absorbs large amounts of water, adding increased loading and lubricating the spoil bank bearing surface. Massive slides have occurred (1966) along 1400 miles of bench as well as innumerable smaller ones.

Auger mining is usually associated with contour mining where the height of the overburden becomes too great to be handled profitably in other ways. Coal is recovered by boring horizontally into the seams with drills that may be as large as seven feet in diameter By adding sections, the augers can be driver over 200 feet into the coal seam. While the method is profitable, augers may leave as

much as 80% of the coal behind. Frequently, however, the augers have chewed up areas that would be needed for mine supports. The seam may be crushed and sealed beyond the reach of shaft operations that might have recovered it when economics demanded. Thus scalping of easy profits has wasted the underground as well as the surface resources.

In addition to the mining itself, the construction of mine access roads adds considerable acreage to the disturbed area. They form approximately 10% of the total. Their use by heavy trucks--up to 100 ton capacity--greatly accelerates erosion, and their usual proximity to natural stream channels increases the problem of stream sedimentation. Studies by the U.S. Forest Service indicated the soil loss rate from sandy roads is about 2.6 inches per year, or equal to about 472 tons per acre per year.

As is true in the exploitation of many other natural resources, the private standards used in strip mining are not concerned with defining social efficiency. Thus, a market failure results because the decisions of strip miners impinge on other individuals in the economy but in ways that are not reflected in their cost calculations. These externalities are costs imposed on others by the mining operation, without compensation, and therefore without the need for the operator to control them. The costs to society, however, are real and significant and they form the heart of the strip mining problem--a problem that can be mitigated in part by the use of organic wastes. These costs include:

(a) Air pollution from dust created by mining operations, wind-blown erosion and smoke from burning waste piles and coal seams

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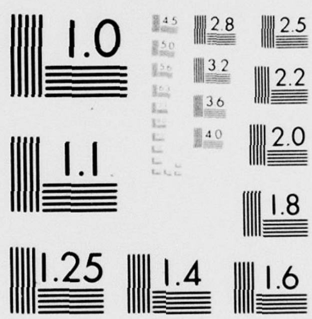

MICROCOPY RESOLUTION TEST CHART
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(b) Water pollution resulting from acid drainage or sedimentation, far more serious than air pollution, affecting thousands of miles of waterways.

(c) Land disruption which destroys forests and agriculture, buries the top soil, creates erosion, increases flood damage, and destroys both human and wild life habitat.

(d) Economic costs which include the loss of other productive opportunities because of stripping and the increased tax burden related to loss of population and reduced access to services.

(e) The social and esthetic effects are in many respects the most severe and permanent. They include the disruption or dislocation of homes and people, the impoverishment of segments of the population, and the destruction or degradation of the character of communities due to the transient nature of strip mining. The effects of the disfigurement of the landscape are visited, in a visual sense, on land areas far in excess of the actual limits of stripping. Some estimate 10 acres are despoiled for every one mined, imposing costs not only on residents but visitors traveling through the area.

It is possible for people to move away and for travelers to avoid the "bad lands" made by the strip miners, but the effects of erosion, sedimentation, and acid mine drainage will continue to blight the regional waterways for generations unless major reclamation efforts are made and future mining is tightly controlled. The removal of vegetation, the destruction of top soil by heedless mixing with subsoil and broken rock strata, the disposal of the overburden in steep piles and ridges, the disruption and block-

age of normal drainage patterns seem almost calculated to spread the degradation. The impact of rain on stripmined land is immediate and catastrophic. Ditches and gullies form on the spoil bank and existing drainage channels are enlarged. Soil losses from unvegetated spoil banks may run as high as 400 tons per acre per year, while forested areas may run less than one.

While successful planting might be expected to control some erosion, spoil bank materials which have a pH of 4.0 or less are lethal to most plants. Almost 80% of spoil banks registered pH 3 to 5. Ideally, a spoil bank will be leached of enough acid in the top layers within 3 to 5 years to allow planting. But during those years, increased erosion is likely to carry off the surface materials as quickly as percolative leaching reduces acidity. Thus the bank continuously presents new surfaces to air and moisture, becoming invariably acidic and resistant to cultivation.

The material washed away from spoil banks will cover vegetation in adjoining downhill areas. In some cases, sediments and coal fines have choked stream valleys until the fields have become swampy and useless for agriculture. There is some indication that filled stream beds and sediment dams are responsible for increased flood damages. Some 60% of headwaters streams examined showed reduced flow capacities and it was estimated that 10% of the stream channels near spoil bank areas were reduced by two-thirds or more. Studies by the U.S. Geological Survey found that the average annual sediment loads transported by larger streams might range from 20 to 3000 tons per square mile of watershed in undisturbed areas while stripmined watersheds would yield about 30,000 tons per square mile, or 10 times the <u>maximum</u> normal amount.

The solid sediments consist of a broad mixture of loose waste rock, earth and mineral matter, including fragments of waste coal. An indication of the magnitude of sedimentation is the fact that some private firms make a profit dredging rivers for coal although coal represents only a fraction of the solid wastes entering the streams. Damage from the transport and deposition of solid wastes includes the destruction of fish habitats, the erosion of bridges and roadways, the reduction of channel capacities, the clogging of culverts, and the undercutting of stream banks. It shortens the life of flood control and water storage projects, and together with acid drainage, degrades water quality and adds to treatment costs of downstream users.

In addition to spoil bank erosion, the disposal of refuse from coal cleaning and preparation plants constitutes a problem associated with active operations. The Bureau of Mines reports that 435 million tons were mechanically cleaned in 1967. More than 100 million tons were discharged as refuse, adding to the load of mine spoil. Pressures for clean air will prompt cleaning of ever higher percentages of raw coal including the lower strip mine grades. Trends suggest that the typical load of coal brought to market will yield ever higher tonnages of waste to add to problems of erosion.

4. Acid Mine Drainage

Acid mine drainage constitutes the most pervasive and widespread external cost resulting from the mining of coal. Acid mine water is produced in both active and abandoned underground and surface coal mining operations. The total damage from stream pollution attributable to strip mine operations alone is not known

but most authorities believe it constitutes more than a quarter of the problem. The U.S. Public Health Service estimated (1962) that 3.2 million tons of sulfuric acid are discharged annually into streams, mostly in the northern third of Appalachia. The Department of Interior indicated in 1964 that 5,000 miles of streams and 13,000 acres of ponds have been polluted by coal mine drainage. Later figures (1969) escalated this total to 12,000 stream miles and 15,000 acres of impounded water, absorbing each year the equivalent of over 4 million tons of sulfuric acid.

Acid mine drainage pollution begins with the exposure of iron sulfide minerals, associated with coal, to the atmosphere during mining. Iron sulfide, commonly known as pyrite, is an intrinsic mineral associated with coal and with the rock strata above and below the coal beds. The relatively insoluble sulfides are exposed to air and moisture during the mining, are converted by oxidation to soluble sulfuric acid and to iron compounds. Secondary reactions take place between ferric sulfate, sulfuric acid and various mineral compounds found in the clays, shales, and rocks associated with the coal beds. The acid mine water, through natural drainage or flow through fractured rock strata enters the receiving streams and undergoes additonal oxidation producing more acid and ferric hydroxide which precipitates out of solution to coat the stream bottoms with a yellow or brown sediment known as "yellow boy."

The sulfuric acid, the iron compounds, and the various other chemicals in mine drainage affect water in many ways. Perhaps the most dramatic are the long reaches of stream that are totally devoid of vegetation or fish life, the fish kills in more distant

rivers, and the overall impairment of stream appearance due to discoloration of the water and deposition of sludges. The damage of the mine drainage to the streams does not end at the point where natural flow dilutes the pollution sufficiently to maintain aquatic life, but continues to lower the productive capacity for many miles downstream.

Damages to aquatic life are generally attributed to the acid, the iron and sulfate irons, and the precipitated iron salts covering the stream bed. However, zinc, copper, and aluminum have occurred in lethal concentrations in acid mine drainage, and arsenic and cadmium have been found at threshold concentrations. The toxicities of these elements are compounded by synergism among several of them: zinc with copper, zinc with cadmium, and copper with cadmium. The toxicities of iron, copper, and zinc solutions are much higher in acid waters, but because of the complex chemical nature of coal mine drainage, it is difficult to assign its poisonous effects to any single constituent.

Acid mine drainage damages water quality by lowering the pH, reducing natural alkalinity, increasing total hardness, and adding undesirable amounts of iron, manganese, aluminum, sulfates, and other chemicals. The net result is to increase the cost of water treatment to both municipal and industrial plants, and to accelerate the deterioration of equipment. High acidity and low pH can interfere with standard water treatment processes. The corrosive nature of the acid drainage causes rapid deterioration of concrete, steel, and iron, slashing the useful life of culverts, bridges, docks, boats, barges, pumps, and condensers. The damage to recreational use and esthetic values will range from complete to partial

and would include the lowering of property values along polluted streams. The potential of many communities for industrial and recreational site development is degraded by poor water conditions.

The volume of polluting mine drainage tends to increase as additional coal is mined. The stripping fractures ever greater areas of overlying rock strata, allowing more surface and ground water to enter into, and circulate through, the voids left by mining While drainage from surface mining may find its way directly to nearby streams, it may also exhibit an intermittent flow. When runoff is trapped, pools form containing high concentrations of pollutants. In subsequent periods of high runoff, these pools will overflow, releasing concentrated "slugs" of pollutants to receiving streams. Although streams that are intermittently polluted may be of good quality much of the time, the aquatic life may be damaged or wiped out. It has been reported that a stream may require thirty months for restoration after a concentrated acid flow of an hour. The damages are much less reversible than are damages from other pollutants. Between flushout periods, the pools may drain slowly through backfill to emerge downslope, or they may enter the ground water, or drain to underground mines thus increasing the flow from these operations. Drainage from refuse piles at coal preparation plants and washing operations constitutes another major source.

Even if strip mining were banned, drainage would continue to flow from inactive mines as long as air, water, and sulfide minerals were available. Pyrite oxidation may be considered as continuous and not dependent on the amount of water which acts chiefly as a

transport agent, dissolving and carrying pollutants into streams. The distribution of pollution is primarily the result of the amount of pyrite materials present and the extent of mining. Increase in mining activity will lead to substantially increased mine drainage pollution loads if corrective measures are not applied. Since acid water continues to be formed for many years after mining is completed, the pollution problem will increase as the number of inactive mines increase. Previously unpolluted streams will be degraded as mining advances into new areas unless effective controls are established over the opening and abandonment of new mines. The potential for further pollution may be indicated by the fact that probably less than 15% of the original reserves have been mined.

5. Reclamation

The foregoing, somewhat lengthy recital of the pollution and degradation caused by strip mining in Appalachia has been included for several reasons:

(a) The conditions indicated are typical of those to be found in the stripmined counties of Ohio.

(b) The continuing urgency and necessity for rehabilitation of stripmined lands in Ohio should be clearly indicated in contrast to other potentially competitive uses of sludge of less significance.

(c) An appreciation of the multiple problems involved in reclamation is essential to avoid a simplistic approach which would be technically infeasible and readily subject to criticism.

The 1965 Report of the Department of the Interior mildly stated that in the framework of the present and future public interest "it must be concluded that past actions by states and local

jurisdications to direct, control and enforce requirements designed to effect the reclamation of disturbed lands have only been partially effective." Yet the failure is not a technical inability. In 1968, a Bureau of Mines report says "Land, disturbed by strip mining of coal, can be reclaimed...and...The reclamation of strip mined land is an effective method for the control of acid pollution and siltation of our natural waterways."

Why then, has the devastation gone unchecked? Some of the reasons advanced are specious at best: failure to recognize water quality control as a major problem, lack of knowledge, mining on steep slopes, or lack of authority to prevent mining in areas where the reclamation is not practicable.

The obvious reasons are the resistance of mining operators to the internalization of the costs of reclamation, the inadequacy of state legislation to force such internalization and the deficient enforcement of even such laws as actually exist. The industry thus far has been exempt from the internalization system the federal government has attempted to institute for controlling air and water pollution.

There is nothing mysterious about reclamation. Proper strip mine regulation would require the land to look and be the way it was before stripping began. Highwalls would be eliminated and the land would be restored to its original contour. Pyritic materials and rocks would be buried. Topsoil would be segregated and replaced after mining. Proper drainage and settling ponds would be installed to prevent acid pollution and sedimentation while vegetation became reestablished, and high performance bonds would be maintained for

enough years to protect against the high rate of failure presently common in such projects. The true measure of adequacy in reclamation is a return to a productive state equal to the pre-mining condition.

This standard has unfortunately, not yet been approached. Indeed, the criteria for reclamation have been so vague and so loosely applied as to inhibit any real analysis, either of costs or effectiveness. The report, "Surface Mining and Our Environment," indicated that reclamation programs were insufficiently broad in scope. The limited objectives sought did not take into consideration all aspects of the environment, did not contribute materially to overall watershed development, and did not consider long term objectives. Tree planting, for instance, though possibly effective in screening spoil banks from a distance, cannot control erosion or acid production, and the mass planting of single species affords no cover for wildlife. The Forest Service reported 12% of spoil banks from contour stripping had collapsed into landslides and that vegetation did not improve their stability. Regrading alone can have some success in reducing erosion. It is significant to this report, however, that only 5% of the 693 sites inspected for the 1967 report had been regraded to a contour that would permit the use of agricultural equipment.

The estimates of reclaimed land in strip mined areas are scarcely reliable. Ohio authorities reported in 1965, for instance, that over two-thirds of their "disturbed" land had been completely reclaimed. Yet reclamation may range from simple bulldozing of spoil against a highwall to the redevelopment of field and forest.

The 1965 Department of Interior report stated that "many areas reclaimed, would be considered only partially restored if judged by criteria other than specific legal requirements." Reclamation standards have changed frequently with experience, research, and as environmental demands have gained political power.

Various publications of the federal government have suggested criteria for rehabilitation from "basic" reclamation to preparation for so-called special purpose uses. In some publications, basic reclamation is defined as water quality control through proper mine water drainage, the covering of toxic materials, and the revegetation of pit and spoil bank areas. This does not mean or imply the restoration of terrain to its original contour but is concerned primarily with the control of acid pollution and siltation of streams and rivers. It would include minimum grading to establish non-eroding gradients and to cover coal seams and other sources of toxic material, but not to restore the land to any useful purpose. Additional measures include planting to achieve quick protective cover, drainage control to prevent saturation of spoil banks and ponding on benches, slide damage repair (in acknowledgement of the damage already caused to homes, streams and roadways), repair of mine roads and stream channels, stabilization of about 145,000 acres of existing ponds, and (in some concern for public safety) the fencing and posting of warning signs on highwall edges.

Basic reclamation will not return the land to any useful purpose. Agricultural uses will require extensive grading, not to exceed a 15% grade and smooth enough to allow the operation of farm equipment for planting and harvesting, the burial of large rocks,

the incorporation of fine material and organic matter in the top six inches of spoil, proper drainage and fertilization for satisfactory initial survival and growth. If wildlife refuges are planned, specific game food and cover plantings will be needed. Recreational uses will require additional development as will any projects that involve eventual occupancy.

The new Ohio Strip Mine Law, Chapter 1514 of the Ohio Revised Code, contemplates more than basic reclamation, but leaves considerable discretion to the Chief of the Division of Forestry and Reclamation as to when, how, and whether the reclamation will be carried out. The law provides for the segregation and replacement of the top soil, the immediate covering of toxic materials and the prevention of pollution, "substantial" erosion or sedimentation, land slides and the accumulation or discharge of acid water. The mine operation shall reclaim the area in accordance with a plan filed at the time of obtaining the state license to mine, by contouring (unless exceptions are made), replacing topsoil, burying rocks or other material which would interfere with future use, and planting and growing vegetative covering as required. The plan for mining and reclaiming will include a statement of the intended future use of the area, which will be approved if it places the land "so as to have an equal or higher economic or public use than if the area were to be reclaimed by contouring, that the steepest highwall slope and other grading is not greater than thirty-five degrees <u>except as necessary for the intended future use</u>, that the plan does not pose an actual or potential threat of water pollution or detrimental environment impact....."

It is to be hoped that the discretionary powers in the new Ohio law will be interpreted and used to secure genuine reclamation. Unfortunately, the past history of regulation, even in states with strong laws, has not indicated a sense of total public interest as opposed to the will of the private coal companies. A bonding system, for instance, is common to the laws of all the Appalachian coal mining states. Yet its use has been ineffective. Bonds generally are standard and are not varied according to the nature of the land, the mining method, the reclamation problem, or the past performance of the operator. There has been no attempt to use bonds as a device to gather land into planned reclamation areas. One strip pit could be reclaimed for forest--the adjacent one for something else. In many cases the bonds have been set so low that it is cheaper to forfeit than reclaim. Finally, bonds are usually returned on the basis of certain activity, not of accomplished reclamation. While these deficiencies may not apply to Ohio, the Cleveland Plain Dealer of February 6, 1973 cites numerous failures and deficiencies in the enforcement of the reclamation law enacted in April, 1972.

To reiterate, the use of organic sludges for the reclamation of thousands of acres of previously strip mined land is both appropriate and essential. It will replace the organic material now irretrievably buried with the top soil, and provide the fertilization necessary to successfully revegetate the ravaged areas. Such use should be preceded by comprehensive land use planning, massive recontouring appropriate to its planned use, effective drainage and erosion control, and other efforts, now considered only in "special purpose" reclamation.

6. The Public Interest

The interests of the public in strip mine reclamation are many and diverse. Coal could be our key energy source, at least until the mid-1980's, if reports about federal plans to reduce reliance on oil imports are correct. Demand will probably rise from the 590 million tons produced in 1972 by 40 million tons in 1973, and industry estimates range from 2 to 3 times that production by 1985. Already, the area of land needing reclamation is characterized as equivalent to a mile-wide band from New York to California. As the Secretary of the Interior has pointed out, the entire landscape is disfigured where one acre in ten is land waste. Whatever else strip mining may be, it is unbelievably ugly. There is no environmental insult that so offends the eye.

We are coming to realize that our land resources are not unexhaustable. The public need for recreation lands and open space is increasing and the loss of land from strip mining may become too great to be supported. John Stacks estimates that land equivalent to four-fifths of the State of Connecticut will be stripped nationally bu 1980, given current demands and production practices.

The social effects of strip mining are more localized. The adverse environmental costs are not only externalized by the industry, but localized in the producing rather than the consuming ecosystem. Environmental degradation from strip mining tends to be discriminatory, unfairly burdening those in the vicinity who may not be either consumers or beneficiaries in any way of the resource being exploited. Thus major losses in land value, submergence of personal income levels, swollen welfare rolls, and poor public services are typical

statistical conditions in coal-producing counties. Very few economic benefits trickle down from strip mining and this includes employment. Strip mining is not a labor intensive industry and its machines have systematically displace hundreds of thousands of miners over the last several decades.

It is suggested that this localization of effects, in conjunction with the fact that the costs of coal-associated externalities are small relative to overall industry revenues, focuses concern on the redistribution of those costs. Both ecological and financial redistribution might be achieved by the strictest control of mining and by internalizing costs of extraction so consumers would bear the burden. The rate of return on investment in strip mining activities is relatively high compared to those realized by other industries. It has been estimated that one foot of coal under one acre of land produces 1800 tons. In Ohio, where average seams are four feet in thickness, 7,200 tons could be produced per acre. At $6.00 per ton, gross receipts per acre would amount to $43,200. In contrast, the highest estimates of cost for complete reclamation, an ideal approached not in this country but in Germany, range from $3,000 to $4,500 per acre, or from 7% to 10% of gross receipts in this example.

While strict controls may result in land restoration in future stripping, the problem of acreage presently ravaged and unreclaimed is less amenable to correction. Most of this land is in private ownership and a significant percentage is in holdings of less than 500 acres. It may become necessary for the state to acquire land in order to rehabilitate it, and the problem of determining owner-

ship may be difficult. The new Ohio law provides that the state may purchase or acquire as a donation, any stripmined area which then shall be reclaimed for a useful purpose.

Alternatively, the question of unwarranted financial gain to private owners may arise in a reclamation program. Consideration might be given to securing the public contribution to the cost of rehabilitation by lien or easement, if outright title cannot be obtained. In order to achieve any permanent benefit, or to develop such lands into useful preserves or recreational areas, it would be necessary to exercise some degree of control over adjacent lands. Although in total, millions of acres have been disturbed, strip mines individually may not be highly concentrated. Each may involve only limited acreage and be widely separated from others. Such isolation would greatly restrict their use potential unless easements were obtained, giving government the authority to use or manage adjacent lands. The requirement for state land use planning prior to reclamation becomes especially significant under these circumstances.

7. Coal Mining in Ohio

Coal has been mined in Ohio for more than a century and a half, beginning with a strip mine near the village of Tallmadge in Summit County in 1810. Drift mining began about 1820, and large scale mining was underway in the Mahoning valley by 1850. In the 1880's, Ohio was producing ten million tons per year and ranked third in the nation in the production of bituminous coal. Coal mining expanded rapidly in eastern and southeastern Ohio in the late 19th and early

20th centuries. In 1930, Ohio ranked sixth in production, but the depression caused the closing of many mines.

The industry revived during World War II, but the postwar era again saw a decreasing demand for coal due to a shift to other fuels. The decrease was accompanied by increased mechanization in mining which combined to slash employment by 50% between 1950 and 1960. The demands of the power companies revived the coal industry of the state in the early '60's and production gains have been marked annually. Most of the coal is used for steam generation, but a significant fraction is consumed in coke plants. In 1969, Ohio's annual coal production reached a new peak of 51 million tons, since exceeded.

Surface mining has come to dominate coal production in the state. During 1967, Ohio ranked third in the nation in the output of strip coal. In 1969, a new record high of 32,575,000 tons, 64% of Ohio production, was obtained from strip and auger mining. Recent reports have indicated production has climbed to 36 million tons and more than 70% of the state total. A review of Table 1, Selected Mining Characteristics, indicates that most Ohio counties reflect the preponderance of stripping. The use of strip mining methods is likely to increase as the production of coal increases. Reserves of more than 1,033 million short tons of strippable bituminous coal were estimated in 1968, about 7-1/2% of the national supply. All of the beds are moderate to high in sulfur content, ranging from 2-7%. There are no strippable reserves of low sulfur coal in Ohio.

The Ohio Development Department's 1968 report on "Mining in Ohio" states "the upward trend in coal demand by electric power

TABLE 1. COAL MINING CHARACTERISTICS - SELECTED STRIP MINED COUNTIES

	Strip-Mined Land		Coal Production, by method (in short tons) 1969[2]				Value Added in Mining (million$)[3]*	
					SURFACE			
	sq.mi.	% of county	ALL METHODS	UNDER-GROUND	STRIP	AUGER	1963	1967
Belmont	36.4	6.75	14,109,302	6,735,428	7,274,204	99,670	23.1	40.0
Carroll	8.9	2.25	362,402	300	346,771	15,331	NA	NA
Columbiana	30.9	5.77	1,160,951	44,696	861,079	255,176	5.4	3.5
Coshocton	27.2	4.83	2,773,284	432,053	2,234,787	106,444	8.9	10.6
Guernsey	6.8	1.28	58,015	103	57,912	-0-	NA	NA
Harrison	76.6	18.63	10,923,722	6,116,164	4,657,143	150,415	26.6	32.7
Jefferson	41.8	10.17	5,148,433	879,483	3,952,847	316,103	12.0	15.3
Morgan	20.8	4.94	825,624	703	824,921	-0-	NA	NA
Muskingham	21.7	3.23	2,770,617	52,599	2,655,602	62,416	3.8	5.6
Noble	20.0	4.95	2,756,534	-0-	2,441,042	315,492	3.5	3.6
Perry	27.1	6.60	3,303,699	2,570,547	622,659	110,493	9.2	9.2
Stark	17.6	3.02	353,357	-0-	323,474	29,883	5.3	6.4
Tuscarawas	35.9	6.28	2,502,774	261,094	1,969,118	272,562	8.1	13.8
TOTAL OHIO	441.7	1.07	51,193,208	18,618,334	30,972,280	1,782,414	223.9	281.4

*Value added is reported for total mineral industries, not exclusively coal mining. However, in most cases the county's total value added is derived from bitumonous coal and lignite mining

Sources: 1. Land Treatment - Phase 1 Report, Wright-McLaughlin Engineers June 1972
2. Ohio Department of Industrial Relations, 1969 Division of Mines Report, Table 3
3. U.S. Department of Commerce, Bureau of the Census, Census of Mineral Industries, 1967, OHIO

companies is expected to continue at such an accelerated rate that some estimates of coal requirements for this purpose within the next 15 years range close to 800 million tons per year." Several Ohio utility companies have signed 15-year contracts with coal corporations to supply coal at an increasing annual rate. The same report states that the principal fuel and power consuming industries of Ohio, especially primary metals, chemicals, pulp and paper, petroleum and coal products, and stone, glass and clay producers consume 85% of the total fuel, and 75% of the electric power of the state. While these figures have changed in the last several years, they indicate the unrelenting demand for coal.

While employment in mining generally has retained the same percentage relationship over the state, employment in individual coal mining counties has shown a decrease. (Table 2) The Department of Natural Resources has indicated the 1972 seasonal average employment in coal mining amounted to only 9,477 persons. Greater capacity stripping equipment has tremendously increased the productivity per mine, per hour, and per employee. Ohio strip mining has been most adaptable to large scale equipment, introducing 180 cubic yard shovels and larger, increasing the power and capacity of smaller shovels, and using much auxiliary equipment such as trucks, bulldozers, coal drills, rippers which have lowered the cost of stripping. The mechanization has more than compensated for the smaller number of workers and has increased the average number of coal mining days each year to more than 220.

The effect of strip mining on Ohio lands has been catastrophic but the exact size of the problem remains uncertain. The Ohio

TABLE 2. EMPLOYMENT BY INDUSTRY, 1960-1970 - SELECTED STRIP MINED COUNTIES

Selected Industrial Composition Data

COUNTY	Agriculture 1960	Agriculture 1970	Mining 1960	Mining 1970	Manufacturing 1960	Manufacturing 1970
Belmont	1225 (4.6%)	828 (2.9%)	2563 (9.7%)	3221 (11.4%)	7629 (28.8%)	7047 (28.2%
Carroll	993 (14.4%)	495 (6.4%)	199 (2.9%)	165 (2.1%)	2738 (39.6%)	3511 (45.5%
Columbiana	1684 (4.5%0	1196 (3.0%)	843 (2.2%)	460 (1.2%)	16,949 (45.3%)	17,773 (44.8%
Coshocton	1260 (11.1%)	778 (6.3%)	408 (3.6%)	311 (2.5%)	4322 (38.2%)	5185 (42.0%
Guernsey	1020 (8.3%)	374 (2.8%)	201 (1.6%)	563 (4.3%)	3651 (29.8%)	4559 (34.7%
Harrison	679 (11.4%)	287 (4.9%)	1087 (18.2%)	1321 (22.6%)	1477 (24.7%)	1193 (20.4%
Jefferson	630 (1.9%)	373 (1.1%)	1434 (4.4%)	1037 (3.2%)	13,274 (40.5%)	12,178 (37.3%
Morgan	685 (17.2%)	293 (7.8%)	257 (6.4%)	248 (6.6%)	850 (21.3%)	1075 (28.7%
Muskingham	1243 (4.6%)	724 (2.6%)	574 (2.1%)	565 (2.0%)	9459 (35.0%)	9312 (33.3%
Noble	741 (22.2%)	335 (10.0%)	240 (7.2%)	356 (10.6%)	661 (19.8%)	756 (22.5%
Perry	670 (7.9%)	255 (3.0%)	610 (7.2%)	613 (7.2%)	3225 (38.2%)	3609 (42.7%
Stark	2313 (1.9%)	1585 (1.1%)	395 (0.3%)	408 (0.3%)	53,481 (44.2%)	59,262 (41.9%
Tuscarawa	362 (1.4%)	737 (2.7%)	704 (2.7%)	614 (2.2%)	10,717 (40.8%)	11,528 (41.6%
TOTAL OHIO	129,162 (0.5%)	83,574 (2.0%)	19,278 (0.5%)	21,111 (0.5%)	1,295,892 (36.9%)	1,447,586 (35.6%)

Sources: U.S. Bureau of the Census, U.S. Census of Population: General Social and Economic Characteristics, OHIO, 1960 and 1970

Board of Unreclaimed Strip Mine Lands estimates over 100,000 acres, but other estimates of acreage requiring genuine rehabilitation run considerably higher. Tables 1 and 3 give variable indications of stripmined land between 1960 and 1972 estimates. To the 1964 Department of Interior Report of 179,000 "disturbed" acres in Ohio, the State Division of Mines estimates 10,000 acres are added annually The Ohio Division of Forestry and Reclamation states that 12,700 acres were added in 1970 and 13,000 in 1971. The total acreage requiring rehabilitation is probably well over 200,000 acres. To this impressive total, one must add the estimated 1200 miles of streams degraded by strip mining, the loss of 68,000 acres of wildlife habitat, and the host of accompanying problems typical of Appalachian strip mined areas.

One must reject earlier state estimates of reclaimed acreage. As an example, a site on Upper Meander Creek in Mahoning County has been mined entirely by stripping. Required reclamation was completed in 1962, with grading to a moderately rolling terrain, and plantings that included trees. By 1971, the revegetation process had largely failed, leaving most of the site devoid of tree and grass cover, and subject to rapid runoff and severe erosion. The remaining high wall has dammed acidic pools which are a source of a continual discharge into the creek. Water from the area has a pH below 3.0 and a total acidity in excess of 1,000 grams per liter. This is from a strip mine site at which all legal requirements for reclamation had been met.

TABLE 3 LAND USE - SELECTED STRIP MINED COUNTIES

County	Total Area	Total Urban	Non-urban Total	Mfg.	Mining &Extr.	Commercial
Belmont	344,960 (100%)	5,600 (1.6%)	339,300 (98.4%)	10 (0.002%)	11,430 (3.3%)	30 (0.008%)
Carroll	253,440 (100%)	860 (0.3%)	252,580 (99.7%)	80 (0.3%)	4,520 (1.8%)	--
Columbiana	342,400 (100%)	9,360 (2.7%)	333,040 (97.3%)	110 (0.03%)	10,570 (3.1%)	20 (0.006%)
Coshocton	360,320 (100%)	3,010 (0.8%)	357,310 (99.2%)	190 (0.5%)	9,680 (2.7%)	70 (0.02%)
Guernsey	338,560 (100%)	2,350 (0.7%)	336,210 (99.3%)	70 (0.02%)	3,500 (1.0%)	20 (0.006%)
Harrison	263,040 (100%)	480 (0.2%)	262,560 (99.8%)	340 (0.1%)	35,170 (13.4)	--
Jefferson	263,040 (100%)	6,700 (2.5%)	256,340 (97.5%)	350 (0.1%)	14,450 (5.5%)	30 (0.1%)
Morgan	269,440 (100%)	--	269,440 (100%)	320 (0.1%)	5,920 (2.2%)	10 (0.004%)
Muskingham	428,800 (100%)	4,980 (1.2%)	423,820 (98.8%)	70 (0.1%)	5,780 (1.3%)	20 (0.005%)
Noble	258,560 (100%)	--	258,560 (100%)	20 (0.008%)	6,390 (2.5%)	--
Perry	262,400 (100%)	1,660 (0.6%)	260,740 (99.4%)	270 (0.1%)	7,540 (2.9%)	20 (0.007%)
Stark	371,840 (100%)	20,940 (5.6%)	350,900 (94.4%)	1,620 (0.4%)	7,990 (2.1%)	470 (0 .1%)
Tuscarawas	365,440 (100%)	6,110 (1.7%)	359,330 (98.3%)	540 (0.1%)	10,610 (2.9%)	--
TOTAL OHIO	26,381,670 (100%)	1,138,870 (4.3%)	25,242,800 (95.7%)	22,450 (0.08%)	194,590 (0.07%)	7,130 (0.03%)

Source: Ohio Development Department, Planning Division, 1960 Detailed Land Use Data

TABLE 3 (Cont.)

County	Non-Urban					
	Transp.& Utilities	Institu-tional	Recrea-tion	Water& Wetlands	Agric. &Other	Residential
Belmont	5,060	2,930 (0.8%)	1,190 (0.3%)	2,920 (0.8%)	307,820 (89.1%)	7,910 (2.3%)
Carroll	1,920 (0.75%)	2,600 (1.0%)	310 (0.12%)	2,440 (0.96%)	238,560 (94.1%)	21,150 (8.3%)
Columbiana	3,440 (1.%)	130 (0.04%)	5,320 (1.5%)	2,240 (0.6%)	299,760 (87.5%)	11,450 (3.3%)
Coshocton	2,640 (0.7%)	6,090 (1.7%)	2,150 (0.6%)	250 (0.7%)	333,270 (91.7%)	2,970 (0.8%)
Guernsey	4,140 (1.2%)	1,210 (0.36%)	15,300 (4.5%)	2,240 (0.7%)	305,080 (90.1%)	4,650 (1.4%)
Harrison	4,130 (1.5%)	10,610 (4.0%)	1,480 (0.5%)	5,140 (1.9%)	203,650 (77.4%)	2,040 (0.8%)
Jefferson	2,750 (1.0%)	340 (0.1%)	5,610 (2.1%)	1,070 (0.4%)	222,330 (84.5%)	9,310 (3.5%)
Morgan	2,110 (0.8%)	30 (.01%)	8,180 (.03%)	580 (0.2%)	250,840 (93.1%)	1,450 (0.5%)
Muskingham	4,700 (1.1%)	6,310 (1.5%)	7,410 (1.7%)	5,550 (1.3%)	385,740 (89.9%)	8,240 (1.9%)
Noble	2,320 (0.9%)	2,470 (0.9%)	1,220 (0.5%)	3,690 (1.4%)	240,770 (93.1%)	1,680 (0.6%)
Perry	2,650 (1.0%)	220 (0.08%)	21,150 (8.1%)	1,520 (0.6%)	223,470 (85.2%)	3,900 (1.5%)
Stark	5,230 (1.4%)	2,640 (0.7%)	2,090 (0.6%)	1,470 (0.4%)	296,470 (79.7%)	32,650 (8.8%)
Tuscarawas	4,170 (1.1%)	5,770 (1.6%)	80 (0.02%)	4,660 (1.3%)	327,590 (89.6%)	5,910 (1.6%)
TOTAL OHIO	298,040 (1.13%)	158,270 (0.59%)	439,310 (1.66%)	220,100 (0.83%)	23,198,530 (87.9%)	704,380 (2.7%)

TABLE 4 Selected Strip Mined Counties

County	Strip Mined Acreage*	Ohio Development Region
Belmont	23,296	Ohio Valley
Carroll	5,737	Tuscarawas Valley
Columbiana	19,778	Lakeshore Uplands
Coshocton	17,440	Tuscarawas Valley
Guernsey	4,369	Tuscarawas Valley
Harrison	49,064	Tuscarawas Valley
Jefferson	26,772	Tuscarawas Valley
Morgan	13,354	Ohio Valley
Muskingum	13,884	Tuscarawas Valley
Noble	12,835	Ohio Valley
Perry	17,322	Ohio Valley
Stark	11,276	Lakeshore Uplands
Tuscarawas	22,995	Tuscarawas Valley

* Wright-McLaughlin Engineers. Strip Mined Lands In Ohio, Phase II Report, October, 1972.

8. An Area for Reclamation

Among the many Appalachian counties of Ohio, thirteen have been chosen for closer examination. There are several reasons for this selection. First, they include all of the more heavily stripmined areas of the state, those with over 10,000 acres disturbed. Second, they are within 150 miles of the Cleveland-Akron metropolitan area, the presumed source of the sludge to be used for reclamation. Finally, an existing, unused coal slurry pipeline leads from Eastlake to Cadiz in Harrison County. The pipeline, which could be used with little modification, is the least expensive means of sludge transmission; it terminates in a heavily mined county which is also adjacent to counties with over 100,000 acres of strip mined land.

It is useful in listing these counties, to designate the state development region in which they are located, and the estimated strip mined area in each county. (Table 5)

With the exception of Stark and Columbiana Counties, these counties fall within the boundaries of the Ohio Department of Development's Tuscarawas Valley and Ohio Valley Regions. In its 1966 Report on the Ohio Comprehensive Planning Program, both regions were noted as a distinct type within the state, "characterized by rugged, hilly terrain, low population density, small cities, poor transportation systems, and a dependence on agriculture and resource development." The low population density is the result of a population growth rate considerably lower than the state as a whole. Table 5 indicates a net population loss in many countries within the last ten to thirty years.

TABLE 5 POPULATION VARIATION BY COUNTY - 1900-1970 (SELECTED STRIP MINED COUNTIES)

COUNTY	1900	1910	1920	1930	1940	1950	1960	1970
Belmont	60,875	76,856	93,193	94,719	95,614	87,740	83,864	80,917
Carroll	16,811	15,761	15,942	16,047	17,449	19,039	20,857	21,579
Columbiana	68,590	76,619	83,131	86,484	90,121	98,920	107,004	108,310
Coshocton	29,337	30,131	29,595	28,976	30,594	31,141	32,224	33,486
Guernsey	34,425	42,716	45,352	41,486	38,822	38,452	38,579	37,665
Harrison	20,486	19,079	19,625	18,844	20,313	19,054	17,995	17,013
Jefferson	44,357	65,423	77,580	88,307	98,129	96,495	99,201	96,193
Morgan	17,905	16,097	14,555	13,583	14,227	12,836	12,747	12,375
Muskingham	53,185	57,488	57,980	67,398	69,795	74,535	79,159	77,826
Noble	19,466	18,601	17,849	14,961	14,587	11,750	10,982	10,428
Perry	31,841	35,396	36,098	31,445	31,087	28,999	27,864	27,434
Stark	94,747	122,987	177,218	221,784	234,887	283,194	340,345	372,210
Tuscarawas	53,751	57,035	63,578	68,193	68,816	70.320	76,789	77,211
TOTAL OHIO	41,575,545	4,767,121	5,759,394	6,646,697	6,907,612	7,946,627	9,706,392	10,650,903

Sources: 1900-1960 - Statistical Abstract of Ohio, 1969, Economic Research Division, Department of Development, State of Ohio

1970 - 1970 Census of Population, Final Population Counts, Ohio PC (VI)-37, Bureau of the Census, U.S. Department of Commerce

The Tuscarawas Valley serves as a transitional region between the heavily populated northern counties and the sparsely settled Ohio Valley Region to the south. Much of the land is rugged. Stream and river valleys generally have steep valley walls flanking broad, flat valley floors. Several major rivers cross the region, draining to the Ohio River. Major waterways include the Licking, Muskingum, Mohican, Walhonding, and Tuscarawas rivers. The region is rural in character. Agriculture is an important source of employment in the region, though the hilly character of the land limits productivity. Considerable strip mining has and is occurring in most counties.

All counties in the Ohio Valley region are characterized by steep to rough topography. Forest cover is extensive and the high bluffs overlooking the Ohio River provide an extensive scenic corridor. Due to the topography as well as the low population density in the area, there is no developed transportation network or road system. The southeastern portion of the area which includes the counties of concern is predominantly rural with the main economic activity in mining and lumbering. Coal mining activity is scattered throughout the region and is of growing importance. Many rivers cut through the Ohio Valley Region, flowing generally south to the Ohio River. Those of particular interest are the Hocking and Muskingum and their tributaries.

The thirteen counties are in a region comprising the steep, hilly, Appalachian Plateau. The steep slopes and nattow ridges cause rapid runoff and erosion during intense rains despite the moderately rapid permeability of many of the soils. The soils are largely residual sandstone and shale. Much of the land is too steep or

shallow for cultivation, so a relatively high proportion of it must be devoted to forest or pasture. Hay and grains may be produced on gentler slopes if conservation practices such as contour strip cropping or terracing are used. Strip mining in these areas will produce erosion, sedimentation and acid drainage problems. While there is internal variation of soils in each county, they range from shallow stony soils along the Ohio River, through low to moderately fertile soils toward the inland area. Large areas are underlain with acid shale which reduces their permeability and responsiveness to good management. The use of erosion control practices when slopes are cultivated is emphasized for all soils in the area.

The 1969 report on "Acid Mine Drainage in Appalachia" states that many streams in eastern Ohio are continuously or intermittently acidic. The Muskingum and Hocking River basins, for instance, have extensive stretches containing continuously acidic water. The characterization of the water pollution problems of each county may be approached by consideration of the separate river basins that drain them: the Muskingum, the Hocking, and portions of the Ohio River main stem and its tributaries. The stream pollution is summarized in Table 6.

Muskingum River Basin: The Muskingum River Basin lies in the eastern part of Ohio. It is formed by the junction of its two principal tributaries, the Tuscarawas and the Walhonding, at Coshocton, near the center of the basin. The total drainage area of the basin is 8,040 square miles, and the river flows south to empty into the Ohio River at Marietta. Nine of the 13 selected counties are drained wholly or in part by this watershed. They include Belmont, Carroll,

TABLE 6 Lengths of Streams Polluted by Mine Drainage

Muskingum River Basin	Drainage Area Square Miles	Continuously Polluted (Miles)	Intermittently Polluted (Miles)	Total (Miles)
Muskingum River Tributaries	8,038	244	59	303
Tuscarawas River Tributaries	2,590	154	34	188
Walhonding River Tributaries	2,252	16	15	31
Hocking River Basin				
Hocking River	1,200	223	141	364
Upper Ohio River				
Pittsburgh to New Cumberland Dam Minor Tributaries	1,609	159	24	183
New Cumberland to Belleville Dam Minor tributaries	3,933	365	38	403
	19,622	1,161	311	1,472

Columbiana, Coshocton, Geurnsey, Harrison, Muskingum, Stark, and Tuscarawas.

Some mine drainage pollution occurs in each of the coal producing counties of the basin. However, Tuscarawas, Coshocton, Muskingum, and Perry Counties are the most seriously affected by continuous acid mine drainage. There are extensive stretches of creeks affected in Guernsey County, and lesser amounts in Belmont and Carroll Counties. Data obtained in 1966 indicated that over 400 tons of acid drainage enter into the streams of the basin each day. Over 500 miles of streams were considered polluted by mine drainage, with 80% of this continuous.

The report comments that most of the coal mine drainage flowing into the Tuscarawas River enters in the reach between Massillon and Newcomerstown. However, the industrial pollution originating in the Akron area affects the river to such a degree that the influence of the acid mine drainage is not easily recognized.

Hocking River Basin: The Hocking River Basin covers an area of 1200 square miles located in the hill section of southeastern Ohio. While only two of the selected counties, Perry and Morgan, are partially drained by the Hocking tributaries, these are continuously and seriously polluted. These include Rush Creek, Monday and Sunday Creeks in Perry County, and Federal Creek in Morgan County. The Hocking River Basin as a whole contains 364 miles of streams significantly polluted by coal mine drainage, two-thirds of which are continuous.

Ohio River Main Stem: The basin areas of the Ohio River main stem include areas of Ohio, Pennsylvania, and West Virginia. The

largest of the tributaries of the area in Ohio include Little Beaver Creek, Raccoon Creek, the Little Muskingum River, and Brush Creek. The counties in their drainage basin include all or part of Belmont, Carroll, Columbiana, Harrison, Jefferson, Muskingum, and Noble Counties. Including out-of-state area, surface and underground sources are estimated to contribute 1000 tons/day of unneutralized acidity to the Upper Ohio and its minor tributaries, with 1300 miles of streams significantly affected.

Sections of Yellow Creek and its North Fork are continuously polluted in Columbiana, Carroll, and Jefferson Counties. Short Creek and Cross Creek are continuously polluted in Harrison and Jefferson Counties. WheelingCreek, McMahon Creek, and Captina Creek are continuously polluted for their entire lengths in Belmont County and most sections of Duck Creek in Noble County are polluted.

The 1966 study characterized streams as continuously affected when they were degraded all or nearly all the time. Intermittent pollution of a significant character was also observed. It is recalled that intermittent pollution can be as devastating to stream life as a continuous flow. There is an implicit assumption that there is a proportional relationship between cumulative coal production and the annual volume of acid mine drainage. Such relationship will be dependent upon the amount of pyritic materials associated with the coal. Nevertheless, no decrease in the amount of pollution can be expected in the absence of specific control measures.

9. Regional Development

The conclusions of the Appalachian Regional Commission have not been in the direction of supporting a massive attack on mine drain-

age pollution, in spite of the fact that they recognize "improving stream quality may be one of the essential steps to transform an area so it will attract private investments in recreation, industry, or housing." Within the Tuscarawas and Ohio Valley Regions the Ohio Department of Development anticipates growth within the context of greater exploitation of the coal reserves. More industry with high fuel requirements would be induced to locate in the south-east in order to give better balance to the economy in this part of Ohio. Mining is indicated as an important locative factor in Ohio manufacturing. Yet a comparison of the value added by mining in Table 1 and Table 2 - Employment by Industry, does not indicate any significant relationship.

There is a major question whether industry can be attracted to an area handicapped by the residuals of stripping. For instance, from the standpoint of industrial water use, acid mine drainage creates many problems and establishes a barrier to industrial location. The importance of the pollutants vary with intended water usage. However, acidity sufficient to reduce the water pH below 6.0 affects almost all water uses. Iron and manganese significantly affect all process uses. The increased dissolved solids reduce water utility for various critical applications, including feed for high pressure boilers. High sulfate values severely limit the number of times that makeup waters could be concentrated in cooling towers and evaporative coolers before sulfate scale becomes a problem.

Techniques for the abatement of mine drainage pollution resolve into only two alternatives: (1) a reduction or elimination at the source, and (2) the treatment of presently polluted waters. A range

of techniques have been suggested and explored in the treatment of pollution, but all of them have presented insurmountable cost problems Even the use of lime in various forms for acid neutralization, though it is economically feasible, presents other problems, including the increase of hardness and calcium and the failure to reduce the manganese content. From an industrial point of view, the reduction or elimination of mine drainage pollution at its source is clearly to be preferred to later treatment.

The Tuscarawas and Ohio Valley regions have the most potential for long term recreational development in the state, but much of this potential will depend on the ability of the state to control and reclaim mining lands. In the meantime, these areas will be dependent on mining more than any other section of the state.

10. Three Counties

The counties of Belmont, Harrison and Jefferson form a compact group in eastern Ohio. They have been the first three counties in the amount of coal mined, in value added in mining, in the amount of land stripped (over 150 square miles), and possibly in the increase in their strip mining activity. A closer look at their characteristics is warranted.

Belmont County. The 1970 Plan for Outdoor Recreation in Ohio, prepared by the Department of Natural Resources, characterizes Belmont County as a rugged picturesque area, blessed with a wide range of natural resources. The Ohio River, with its corridor of steep hills and rugged bluffs, forms the eastern boundary. Vegetation and forest cover on the hills is extensive and the corridor has outstanding potential for recreational development. The eastern half of

the county has open ridge tops, steep wooded ravines, and sheer narrow valleys. Hills and bluffs along the Ohio River rise 300 to 500 feet above the valley floor. The soils of the area are largely shallow and stony on steep and hilly topography. They are not suited to cultivation and the best use of the land is for forestry.

The western half of the county is less rugged, but much of the area is still used for rough pasture and woodlands. The soils of the area have largely developed on sandstone, limestone and shale in a rolling topography. They are moderately productive, adapted to legumes and grasses, but require erosion control practices on any sloping land.

Martins Ferry and Bellaire are the two principal cities in the county. Located along the Ohio, they are more oriented toward Wheeling, West Virginia than any Ohio center. Highway development in the county has been limited by the topography but Interstate 70 provides east-west communication while Ohio 7 along the river runs north and south.

The recreation report says that strip mining has been an important factor in the economy and physical appearance of the county. Nearly 7% of the county had been stripped by 1969 and extensive additional mining was expected. Coal deposits are found throughout the county and the Bureau of Mines 1968 report lists recoverable strippable resources as 258,300,000 short tons with an average seam thickness of 55 inches. A story from the New York Times of December 15, 1970 estimates 200,000 of the total 346,000 acres in Belmont County have already been sold, leased or optioned to coal suppliers. This is the location of the so-called Egypt Valley from

which the Hanna Coal Division of Consolidated Coal strips about 5 million tons per year.

Belmont County is called fortunate in having some 2,000 acres in Piedmont Lake and numerous scenic streams available to the public for water based recreation. Yet all of the major streams draining to the Ohio River are continuously polluted by acid mine drainage. This includes Wheeling, McMahon and Captina Creeks as well as other smaller ones. Drainage into Piedmont Lake carries heavy amounts of dissolved solids including iron, managanese, sulfates and various metals dissolved by the acid drainage. Whether the lake will remain a viable system is open to question.

Belmont County has a great potential--for recreation or for mining. The question is whether the two can be made compatible by strict control of future mining and the reclamation of previously stripped land.

Jefferson County. Some thirty miles of the Ohio River form the eastern border of Jefferson County. Hills and bluffs with rock outcroppings rise 400 to 500 feet above the valley floor. Forest cover is excellent along the entire river which retains a natural configuration except in the Steubenville area. Steep wooded stream valleys running to the Ohio provide additonal scenic interest. The entire corridor offers excellent recreation potential. All of the county is rugged and picturesque, with extensive forest cover. Narrow ridge tops and steep valley walls result in short, fast drainage runs to the Ohio. Soils throughout the county are shallow and stony, and with the steep topography are unsuited for cultivation. The recommended use is for retention in forest cover. Other soils

are interspersed which can be adapted to production of legumes and grasses, but erosion control must be practiced.

The county is dominated by the Steubenville urban area. Industrial development generally has been confined to the river valley, due to the topography which has dictated highway locations and transportation modes, and the water. Principal routes are Ohio 7 on the river and the east-west routes of State 43 and US 22. Local roads in most cases are limited to narrow ridge tops.

The 1970 Ohio Recreation Plan says that strip mining operations have affected 23,000 acres and that active mining is still taking place. A 1972 report indicates that nearly 27,000 acres, over 10% of the county area, have been stripped. The 1968 Bureau of Mines report cites recoverable strippable resources of 315.5 million tons with an average coal seam of 47 inches thickness.

Yellow Creek, in the northern portion of the county, is the most significant interior water course. It is continuously affected by acid mine drainage to the Ohio River as is its North Fork. Similarly affected are Cross Creek, Short Creek and smaller streams tributary to these streams and to the Ohio. A Jefferson County Reclamation Area of 1,000 acres is a pilot project, attempting to deal with the problems of acid drainage, erosion and the need for revegetation.

Harrison County is a rural and sparsely developed county. There are no cities and the largest community is the Village of Cadiz with a 1970 population of 3,060. The topography is hilly, and the soils range from sandstone based soils that require erosion control, in the eastern section of the county, to highly acidic but fertile soils in some western areas. In between there is a variable

section of soils developed on sandstone and shale, that are low in fertility, organic materials and lime. They are generally adapted for hay and pasture crops, but in some areas may be underlain with acid shale, reducing their agricultural response.

Much of the county has been mined for coal. The most recent indication is that nearly 50,000 acres have been affected, more than 18% of the acreage in the county. The 1970 Ohio Recreation Plan says that this has given the county "a rugged, desolate appearance," while the 1972 Ohio Almanac states flatly "much of the county has been spoiled by coal strip mining operations." Further stripping may be expected since 191.4 million tons of recoverable, strippable coal remain, according to the 1968 Bureau of Mines report. The average coal bed thickness in the county was reported to be 51 inches.

The negative impact of strip mining was addressed in the 1969 report of the Harrison Regional Planning Commission. Coal had been mined in Harrison County since its early history, but it did not rank high as a coal producing area of the state until the Hanna Company began its strip mining activities in the 1930's. Due to the large capital investment of the Hanna Company in strip mining equipment of greater size and maneuverability, the county has become a major coal producing area.

Until the beginning of large scale stripping, the county had been basically agricultural and farming still plays an important role in its economy. However, there has been a steady decline in both the number of farms and the acreage due to strip mine activity. Of the 263,040 acres in the county, 160,000 were used for agriculture in 1959. By 1964, only 130,000 acres were devoted to farming and the number of farms had declined from 863 to 662. The county has

declined in population during the past twenty-five years, and much of this has been attributed to the effects of strip mining. In 1940, 20,313 persons resided in the county; in 1970, the population had fallen to 17,013. Losses were recorded in nearly all communities during the period, but the largest losses were registered in those townships where strip mining was active. Of the 1940-1960 population loss, eighty-six percent left from areas of strip mining activity.

In 1968, coal companies owned 20% of the surface of Harrison County, or 53,000 acres. At that time, 44,000 acres had already been stripped with a residual desolation typical of unreclaimed stripmined land. Mining remains the most important economic activity of the county. Although the total is now much lower, the Planning Commission reported a 1967 employment of 2,140 persons in mining, some 36% of employment in the county. In the same year, the mining payroll accounted for 67% of the total payroll in the county.

In spite of the fact that strip mining, past and present, dominates the physical character of the county, the Ohio Department of Natural Resources considers the area to have unusual potential for recreational use. Among its assets are the Clendenning and Tappan Lakes, which are included with over 14,000 acres administered by the Muskingum Conservancy District. There is some indication that pollution may be developing in the watershed, but the most heavily polluted streams are in the eastern part of the county where Short Creek and Cross Creek are continuously polluted on their way to the Ohio River. The Harrison County Reclamation Area is an attempt to repair 1300 acres of land ceded to the state. The control of acid drainage and erosion as well as revegetation is necessary to reclaim what the strippers left as "a totally worthless area."

11. Conclusion

It is to be hoped that the new Ohio strip mine law and its administrators will effectively control the environmental residuals of strip mining in the future, reclaiming the land while its being stripped, to a utility and value equal or higher than its prior use, and will prohibit unequivocally the mining of unreclaimable land. However, the diseconomies that have already been visited upon tens of thousands of acres by the coal miners--the destruction of scenic value, the loss of productive capacity, the banishment of competing uses by either human or wildlife, the unrelenting poisoning of the waters for the distant user, the demoralization of the local community--these remain. Perhaps no other single enterprise inflicts so devastating an effect on so wide a band of human concerns, from the environment through many socio-economic concerns to esthetics and public health. By the same token, all of these self-same ills may be addressed by a long term commitment to an effective reclamation of the devastated land.

The use of sludges from wastewater treatment is obviously not a panacea. Its fuction must be limited to the re-establishment of the organic characteristics of the fertilization of the soil. Nevertheless, it is a vital function on which depends the quick revegetation and its long term establishment to prevent erosion and sedimentation and to limit the oxidation of surficial materials. This phase must be preceded by appropriate backfill, grading and contouring to usable slopes and the establishment of necessary drainage or retention as required.

Yet the quantity of sludge, so overwhelming at a treatment plant, is limited in the face of the task of reclamation. The quantity of

sludge that may be spread will be a function of the soil characteristics, the land use or intended crop, and the type and solids content of the sludges. Some authors indicate that up to several hundred tons per acre may be profitably used on stripmined area. Its effectiveness in this regard has been demonstrated time and again.

The significance of the use of sludges for strip mine reclamation will be two-fold. On the one hand, it will constitute a recognition of a "waste" material as a resource out of place and provide a means for its utilization for the forseeable future. On the other hand, it will become a focal point for a continuing commitment to the stripmined area; part of a multi-purpose response that would relate water resources planning to the solution of a whole array of human problems. It would be an excellent recognition of the Water Resources Council desires that the development of water and water related resources be supportive of the broadest goals and objectives, and not just development for its own sake.

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Attachment C

ANALYSIS OF WASTEWATER PROJECTIONS FOR THE CLEVELAND-AKRON METROPOLITAN AREA

1. Introduction

The projection of future wastewater treatment requirements, the flow and pollution loads from industrial and municipal sources, are the essential criteria for determining the design capacity of all plan alternatives. If planning is to be effective, in terms of achieving water quality objectives on a least-cost basis for the long-range future, an examination of the assumptions underlying the design projections for both municipal and industrial wastewater becomes a critically significant concern in the evaluation process.

The following discussion first outlines the determinants of industrial and municipal wastewater projections as provided for the alternative plans. An examination of recent literature indicates several considerations which serve as a general base from which to assess the reasonableness of these projections: (1) some guidelines relating to use of projections in water resources planning; (2) recent trends in the general patterns of municipal and industrial water uses with indication of potential influences on current water use and wastewater flows; and (3) census projections of population growth, and the relationship of population increases to economic growth and to future pollution estimates. From the standpoint of these general considerations, the factors determining the study area's wastewater projections are analyzed, with attention particularly directed toward the influences for change.

2. Assumptions Relating to Regional Projections of Industrial and Municipal Wastewater

Population projections, an essential determinant of future wastewater flows, were based on the Battelle model which manipulates 1970 census base data with both demographic factors (birth, death, and migration in individual counties and communities) and economic factors (employment, unemployment, and the size of the available labor force affecting the structure of major industrial classification). This population data was used in both municipal and industrial wastewater projections.

Municipal wastewater projections took account of the relationship of land use changes to population increases, with data obtained on land-use projections from local planning agencies and compiled into land-use composition maps for the study area. The per capita flow of municipal wastewater was estimated at 110-156 gpcd (gallons per day per capita) for the study area, based on 1970 population data and on 1970 wastewater treatment plant records (industrial flows deducted). Pollution loads were calculated from current records and other available data. Projections of future municipal wastewater flow and pollution loads were derived from these base factors, with some consideration being given to potential influences on base flows (although no drastic changes from existing patterns were anticipated). Various reuse possibilities were discussed, with the necessity of improved wastewater treatment emphasized before successful reuse could be implemented.

Projections of industrial wasteloads were based on the stated assumption that future industrial wasteloads would be influenced both by industrial growth and by changing water use practices in

industry. An overall forecast was made that productivity will increase, the cost of water will increase, and the rate of employment growth will decrease.

The projections employ population growth and industrial employment, rather than production figures, as an indicator of industrial growth in the study area. Population growth data derived from the Battelle projections previously mentioned. Employment growth is estimated from a preliminary analysis of past trends: between 1940-50, total employment in the six counties of the Three Rivers Watershed grew at an average annual rate of 3.0%; between 1950-60, the rate dropped to an average annual 1.5%; and 1960-70 showed a 0.4% annual average. The future assumption is an expectation of an average annual employment growth rate of 0.7% during the 50-year projection period. Furthermore, unequal growth is expected among industries, with employment in manufacturing estimated at an assumed annual average of 0.3%--one-half the growth rate of the three previous decades. The majority of the growth is anticipated in the Cleveland and Akron areas. Unemployment in the study area is projected to increase from less than 4% in 1970 to 9.4% in 2020.

Concerning changes in water use practices, projections were made suggesting that all industries would employ advanced levels of technology in production methods by 2020, although at different rates within the 50-year period according to their present level of process. For each decade, the number of plants using each level of technology was expressed as a percentage of the total number of plants in the industry. The relationship of advanced technology to water use was assumed to differ between two broad industrial categories: in all industries except the steel industry, waste

volumes and constituent loadings are expected to decrease with the newer technology, while in steel and fabricated metals industries wasteloads will increase with newer technology.

The industrial wastewater projections additionally allow for in-house effort by industry to minimize water use and product spills. Values derived from an unpublished study analyzing several abatement programs from various industries are made part of the projection assumptions--e.g. a 14% decrease in wasteloads is assumed to result from education and in-plant changes. (The projections assume that these changes would be fully implemented by the year 1990 and that no additional decreases due to these factors would be noted after that year.)

Industrial water reuse is given brief discussion, with the note made that recycling incentives are not well established. Treatment of wastes in combined industrial facilities were examined. However, it was assumed that the costs to individual industries of transporting wastes and the potential complication caused by variable changes in industrial manufacturing processes would constrain any successful implementation.

3. Use of Projections on Water Resource Planning--Some General Considerations

Projections of future treatment needs for the design of wastewater management systems have traditionally been determined by straight-line forecasts relating historical water use to projected increases in those variables which determine water use: population, economic activity, some indication of future land use, and any "expected" changes in technology affecting water consumption. However, the accuracy of straight-line projections is inhibited by the

uncertainties associated with those several determinants. Furthermore, significant influences on future water requirements may be unrelated to the variables of historical rates. The introduction of new variables adds to the concern over accurately forecasting system needs. Some basic probabilistic influences not accounted for in straight-line, deterministic projections include the interrelationship of:

(1) socio-economic phenomena and life-style changes--changing growth rates and patterns of distribution

(2) water resources policy and strategies of implementation--response to increased treatment costs, attitudes of intensified environmental awareness, institutional regulation, public education, etc.

(3) technological developments--impacts or water consumption rates and the relative volume and pollution of dicharges, innovations in wastewater treatment methods.

(4) physical phenomena--finite base of water supply, as well as other natural resources related to water use, treatment requirements, etc.

There is an increased awareness in water resource planning of the concept of "alternative futures" in the forecasting procedure. Although methods for projecting alternative futures necessitate probabilistic rather than deterministic modeling, a range of anticipated future outcomes provides a more accurate base for planning than the single-number projection determined by a straight-line model.

Effective pollution abatement strategies are decisive in translating water quality objectives to reality. The present direction

of federal clean water policy anticipates a program of 75% subsidization of municipal treatment facilities, to be planned on a regional scale, with industries contributing their share of treatment and plant amortization costs for wastes discharged to the municipal system. However, a review of recent construction activity has revealed numerous instances of municipal systems designed for substantial over-capacities, as well as unwarranted sewer connections. Furthermore, the regulation of industrial discharges has raised several questions, among them, the necessity of separate industrial treatment or pretreatment, as opposed to municipal systems designed to accommodate the toxic constituents characteristic of many industrial wastes. Appropriate strategies for industrial treatment regulation, e.g., subsidization, surcharges, or other cost alternatives, the probable change in discharges by industry in response to treatment charges and the impact of industrial treatment charges on the regional, national and international economies are also under question. Additionally, concerted efforts have been directed to emphasizing the necessity for the interrelationship of water quality objectives to broader, multi-sectorial planning objectives--a practice rarely found in traditional planning activities.

Considering that achievement of water quality objectives involves the allocation of huge expenditures, and an even greater amount for "zero-discharge" standards, critical concern is directed to providing least-cost alternatives to achieve an effective abatement. Consequently, the development of projections which set the size and capacity of the treatment system, warrant the most critical attention to prevent overdesign and overspending.

The comments of the National Water Commission on the need for adapting the alternative futures concept to planning for water resources, emphasize that a consideration of both needs and opportunities is necessary in exploring alternative futures, e.g., needs being a forecast based on projections of past trends in distribution of population and economic growth; opportunities representing planned departures from such projections to correct imbalances and to take advantage of changing situations. Furthermore, they point out that the uncertainties of probable influences on the future must be consistently assessed in the planning process: "At any particular point in time, planners should recommend commitment of resources only for the short-term future to the maximum feasible degree, and retain as many long-term options as possible."

4. Trends and Future Influences in Municipal and Industrial Water Use

An analysis of current water use as related to major point sources of wastewater will provide an indication of what determines current use patterns and of factors which may alter these patterns in the future.

(a) Municipal Domestic Water Use

Urban water use is generally considered as combined domestic (residential), municipal-public, commercial, and industrial demands. Varying estimates of urban demand can be found; an average of 155 gallons per capita per day for water consumption in cities by the U.S. Geological Survey (1967). However, the variability of urban water demands in different localities is indicated in a 1964 Public Health Service study, evidencing a variance of total use from 477.mgd to 10. mgd in communities of 25,000 and over. The current demand

and future trends were reported for urban water use by the National Water Institute (1968):

Year	Domestic	Public	Commercial	Industrial	Total
1965	73	20	28	36	157
1980	77	18	28	40	163
2000	81	16	28	43	168
2020	83	14	28	45	170

Alternate estimates of proportionate demands of sub-groups of urban water use are reported. A 1955 U. S. Public Health Service Survey of 206 cities reported an average breakdown of: 41% residential; 18% commercial; 24% industrial; 17% public and other use. A Resources for the Future study in the early 1960's estimated urban water demand accounting for only 5% of all water use in 1960 with a breakdown of 60 gpd domestic, 26 gpd commercial, and 25 gpd municipal.

Domestic demand involve the following uses, with proportionate average rates estimated by the U. S. Geological Survey (1964):

Flushing toilets	41%	Washing clothes	4%
Washing & bathing	37%	General household cleansing	3%
Kitchen use	6%	Watering garden	3%
Drinking water	5%	Washing car	1%

An alternative breakdown is provided by a Resources for the Future study team for in-house water uses (1971): drinking and cooking - 5%; bathing and personal uses - 30%; laundry and dishes - 20%; and toilet flushing - 45%.

Although population is the most significant determinant of water demand, factors such as climate, income, type of housing, population density, and price of water have all been shown to have measurable effects on the per capita consumption of water. Wastewater flows nearly match the withdrawal rates for domestic water

supplies, considering that little total depletion occurs among the various domestic-residential water uses. Approximately 89% of all in-house water returns to the sanitary sewage system. However, in estimating the total municipal water use patterns, it has been generally acknowledged that a significant volume may be "unaccounted for water" caused by various municipal water system losses. Although accurate data on "unaccounted losses" is unavailable, a concern for the additive effect on wastewater and for water supply depletion merits attention to loss prevention. Many factors have been found to affect the loss experience of systems, the most prominent being age, materials used in construction, physical and chemical properties of the soil, properties of the water pressure, and programs of past maintenance. Some current research has reported a list of several types of avoidable leakage: (1) broken mains and joint leaks; (2) active service leaks (between the main and customer's meter); (3) leakage from hydrants; (4) inactive service leaks; and (5) sewer flusher leaks.

Recent studies of the major variables influencing current residential water use rates have found that population size, average income and distribution are significant determinants of varying use patterns. Demand rates have appeared responsive to price increases only for sprinkling use, and this relationship is generally restricted to areas where residential water use is metered. In flat-rate areas, peak demands have been found to be more than double those in metered areas because of high sprinkling demands, even in the same climate.

Although future domestic water demands may be directly related to projected population growth, uncertainties associated with fertility rates and life style variations cloud the reliability of long-

range population forecasts. Furthermore, a range of factors not directly expressed in current water use rates will have a probable impact on future domestic water demands and treatment requirement. These considerations include changes in the technology of use, possible regulation and/or increase in the cost of water supply, types and distribution of housing development, and public attitudes concerning environmental quality objectives.

Considering the current trend of use and the increasing types of domestic water-using devices, it may be predicted that the future will bring an increase both in types of technologies and prevalence of their use. At the same time, however, water-saving technologies are currently available to reduce domestic use of some standard water-using devices. The predictability of wide-scale adoption of such technologies is dependent on the economic incentive to the domestic water consumer.

A recent study by Resources for the Future, Inc. examined the relative economics of water-saving devices against standard models, for toilets, showerheads, and automatic washers. The water demands for standard toilet models range from about 3.2 to 8 or more gallons per use. Water-saving models are currently available which use approximately 60% of the volume of traditional models and cost only slightly more. Assuming the current average cost of water at $.40/1,000 gallons, the researchers estimated only a slightly higher expense to the homeowner for replacement, as needed, of normal equipment with a water-saving model, while immediate replacement would involve a relatively substantial expense.

Personal bathing demands an estimated 30% of total in-house water use, with some 60% of that spent showering. Water use in

showering could be halved by adoption of currently available shower heads which restrict the passage of water, presumably without greatly affecting the quality of the bath. While the cost of replacement is minimal to the domestic consumer, the incentive to change may be inhibited by perceived quality deficiencies.

Automatic home washers demand a range of water needs from 32 to 59 gallons per 8-pound load. Lower water-use models are generally more expensive, but the cost is relatively low if purchased as a normal replacement of the less expensive machine with heavy water demand. Consumer response may be significantly related to programs of public education on needs for conserving water. Additional technological advances related to domestic laundering demands include "no-suds" and "no-rinse" washing methods. Although "no-suds" technology is currently available, wide-scale adoption is constrained by consumer perceptions associating cleansing effectiveness with sudsiness. Some potential for future "no-suds" methods may be implied from a growing consumer response to bans on phosphate detergents, indicating an awareness in the public to the need for alleviating water pollution by changes in their domestic habits.

An increasing level of affluence in recent years has been associated with the increases in more in-house water-using appliances as well as both outdoor and indoor swimming pools. That new homes are being equipped with a larger number of water-using fixtures is evidenced by data on FHA-financed single-family homes; in 1959, 50.7% of the new homes and 24.3% of the existing homes had more than one bath; in 1968 the percentages were 71.6% and 40.0% respectively. Food waste disposers, automatic dishwashers and air-conditioners are

among relatively recent technologies increasingly used. The food waste disposer introduced a new in-house use for water and did not, as did the dishwasher, merely mechanize an old job. Both, however, contribute additional demands on domestic water use and wastewater loads.

It is generally acknowledged in the literature that the use of water-saving domestic devices and/or less use of types of water-using technologies will probably be determined more by the response of the building industry than of individual residents. However, an intensification of environmental awareness among the general public may translate to their conserving use of water. Furthermore, water shortages in metropolitan areas may initiate regulation and price increases by municipal water agencies, and thus potentially impact the residential water users' habits.

Housing type and density both influence water use for domestic purposes. Recent analyses suggest that somewhat lower use per capita of water prevails in large urban areas (when industrial use is excluded) than in smaller cities and towns, due to the prevalence of apartments and other multi-family dwellings--this is largely because of less lawn area requiring sprinkling. A further explanation suggests reduction of peak total demands for water in multi-family housing, presumably because the peak demands of individual families occur over a wide spread of time and offset one another. Recent trends to large open-space tracts in PUD's may somewhat offset the variance currently observed in sprinkling demand for multi-family housing.

The distribution of residential land use densities as anticipated for continuation of suburban development will significantly

influence future wastewater treatment requirements. EPA analysts have expressed concern over recent evidence that sewered population is generally rising at a faster rate than population alone, with soil absorption systems being phased out and centralized systems constructed. Although in instances of dense development and poor soil conditions this conversion may be necessary and desirable, analysts caution that for smaller communities, not expected to grow, it may be more economical to renovate the septic tanks and drain fields rather than provide sewer extensions. A related consideration is the recognition that more effective controls are needed in land-use planning, to ensure desirable patterns of development as well as the provision of adequate water supply and treatment systems.

Analysis of current municipal treatment construction activity by the EPA Office of Water Programs, Division of Planning, has led to some expressed opinions by EPA administrators that a "module-construction" approach may be more cost effective than long-range projection designs. It is emphasized that flexibility could be maintained to respond to slower community growth, new technology, or new treatment requirements, with sunk cost minimized and operation costs lower for the service provided. In general, because of the uncertainty attached to long-term population projections--as well as other determinants of future water use rates--the projection period for a wastewater treatment "module" should, according to EPA analysts, be inversely related to the level of interest rates.

(b) Industrial Water Uses

Water uses by industry involve a broad range of activities which generate intensive pollution loads. According to U.S. Geological Survey sources, industry--exclusive of electrical utilities--acounted for 14.5% of water withdrawals in the U.S. from 1950-1965. A comparative estimate is provided by the Water Resources Council, which assess 1965 self-supplied industrial water withdrawals as approximating 17% of all water use sectors. The Council indicates that only some 12% of the fresh water used by industry was purchased from public water systems, with about 76% self-supplied from ground water; some 20% of total industrial withdrawal was obtained from saline sources.

In 1968 about 15.5 trillion gallons of water was withdrawn in the U.S. by manufacturers, which represents an increase of 27.5% from 1959. Of total industrial water use, only some 5-7% is totally consumed; the Water Resources Council has estimated that the manufacturing sector consumed about 2.6 bgd in 1965 through incorporation of water into product, evaporation and unaccounted losses. This average reflects a relatively wide variation of total water consumption rates among different industrial classes.

Water provides a number of productive services within manufacturing processes, which vary among different classes of industries. A number of products, notably beverages and prepared foods, incorporate water directly into the product. Water is used to transport materials in a manufacturing process, and is incorporated in various chemical processes of production. A common use of water by industry is for cleansing purposes, to transport or flush away residual matter which is the inevitable by-product of

manufacturing processes that must be carried away to prevent counter-productive effects. By far the largest proportion of water used by industry is for cooling purposes--over 65% of total industrial water use. Cooling water is used to absorb the heat arising from the difference between thermal energy generated and that used in production. Evaporation resulting from cooling comprises the largest proportion of water depletion from industrial withdrawals.

The most intensive industrial water use occurs among a limited number of manufacturing establishments, which parallels the concentration of industrial output among a relatively few large firms. The Water Resources Council reports that less than 10% of total establishments in the manufacturing sector accounted for over 75% of total production in 1965. Similarly, water use was concentrated among 8,925 establishments each reporting an average water withdrawal of 55,000 gpd or more, accounting for nearly 98% of total industrial water withdrawals (as reported by 1964 Manufacturing Census data). Furthermore, the most intense water demands occur within a narrow range of particular industries--in 1964, census data indicates that 5,154 establishments among 5 major industry groups (food and kindred products, pulp and paper; chemicals; petroleum and coal products; and primary metals) accounted for 88% of total industrial water withdrawals.

Industrial sources contribute a large portion of present overall water pollution. A 1970 EPA national assessment attributed nearly 30% of observed pollution in stream bodies to industrial sources. However, both the volume of wastewater and pollution loads vary among industrial classes; variance among individual industrial sources is influenced by several factors, including rates of evap-

oration, degree of recycling and in-house water management practices.

A major determinant of industrial water use is the level of industrial output, and recent trends can be observed for the heavy water-using industries, relative to production growth. Over the period 1959-1968, the Federal Reserve Board Index of Industrial Production for "Manufacturing" classes increased 59%, and for the five major water-using industries, *relative production growth was:* Food and kindred products, 29%; Paper and allied products, 49%; Chemical & allied products, 94%; Petroleum & coal products, 33%; Primary metals, 52%. Not surprisingly, industrial water intake over the same interval increased for most industries, and in most regions of the country. However, the 1972 EPA Cost of Clean Water reports that growth in production alone does not account for the variation in rates of water intake increases across regions and across industries. Their analysis of the data reveals that, for the period 1959-68, the percentage variation in water intake growth explained by growth in value added (production) are only 18 and 21 percent for regions and for industries, respectively, neither of which is statistically significant--eg. growth in water withdrawals by industry has not been primarily conditioned by growth in industrial production.

Such evidence leads to the assumption that industry has responded to incentives to economize on water intake, possible in response to the price of water. Further EPA analysis of the data finds that the increased cost of water supplies significantly correlated with industrial practices to increase the productivity of water, both by process changes and recycling of water.

The discharge of industrial wastes similarly was found to generally be lower proportionate to production growth, but the relationship was not as clear. Several conflicting findings emerge in the examination of industrial water use related to wastewater discharge that is treated was estimated as 37% of discharge in 1968; however, waste treatment growth was less between 1964-68 (3.1 percent annual rate of increase), than between 1959-1964 (10.5 percent annual rate of increase). The portion of industrial effluent discharged to public treatment facilities dropped from almost 9 percent in 1959 to little more than 7 percent in 1968. In attempting to explain industrial discharge rates as a response to institutional water quality regulations and cost of treatment, the relationship was not as clear as water intake decreases explained as a response to increased water prices. Also, the pollution characteristics of the industrial discharges have been found in some cases to be intensified as a result of process modifications and/or recycling, although wastewater volumes may decrease.

The assessment of charges for treatment of industrial waste in municipal facilities at rates equal to the municipal cost of treating the industrial wastes may partially explain the lower percentage of industrial discharges to public facilities. However, whether this directly causes more economizing on water in industrial processing is not readily apparent. A recent study on the impact of surcharges, (costs levied by municipalities on industrial wastes) revealed the following average results for cities of varying sizes and locations:

1. 45% reduction in pounds of BOD per $1000 value added in manufacturing would be expected if a modest surcharge of $27.00 per 1,000 pounds of BOD were introduced where none had been used before. This surcharge could also result in a 42 percent reduction in water usage.

2. At this average surcharge of $27.00, an increase of 10% in the surcharge (above and beyond the rate of inflation) would be expected to cause an 8 percent reduction in wastes and a 6% reduction in water use. The imposition of surcharges could have even larger effects if industry finds it easy to move to another city. (The figures here assume the cost impact is not great enough to cause industry to relocate.)

3. Assuming a gross marginal price of water of $.40 per 1,000 gallons, a 10 percent increase in the real water rate (above and beyond the rate of inflation) would be expected to cause a 7% reduction in water usage and about a 10% reduction in the pounds of industrial wastes.

Considering these current trends which demonstrate changing rates of industrial water use and discharge, accurate projections become complicated. Therefore, recognition of potential future influences becomes a critical concern.

While industrial water use is mainly a function of production growth, straight-line projections must adjust to uncertainities associated with underlying assumptions of population growth rates and employment, as well as potential technologies which may affect water use in industrial production processes. Furthermore, the stringency of federal clean water policy imposes treatment require-

ments and costs which will predictably impact industrial water usage, and relative discharge rates to municipal treatment systems. However, the degree and direction of potential impact is further complicated by a complex range of factors difficult to accurately forecast.

An important consideration is the type of strategy employed to implement water quality standards for industry. Recent analyses debate the potential effectiveness of various strategies, including alternative or combined use of effluent fees, legal enforcement, surcharges, subsidization, tax reliefs, etc. Although the literature provides numerous discussions from both private and government research interdisciplinary perspectives, detailed discussion is not possible in this report. However, it may be generally noted that differing impacts of industrial behavior generally relate to the type of incentives provided for economizing use of water in production and attempting to lower treatment costs. Clean water policy may deter the adaptation of otherwide pollution-and/or water use-increasing technological innovations and also stimulate development of more efficient production technologies.

5. Population Projections

Population projections are an essential underpinning for estimating future water use rates. Therefore, a brief analysis is here presented. U.S. Census reports on lowered future population growth assumptions, and the relationship of decreasing population growth rates to future economic activity. The associated levels of water pollution will then be indicated, with some consideration of the potential changes from technological development. From this framework, the impacts of federal clean water policy on future water use rates can be considered.

U. S. Bureau of the Census population projections have been lowered consistently during the past several years, primarily due to the trend from the 3-child to 2-child average families. Two years ago Census statisticians reported a projected 1985 population of 242.5 million; current estimates have been lowered to 236 million. The differences in anticipated population increases relative to varying birth rate assumptions are demonstrated by Bureau of the Census projections for the four currently-used levels:

	Year 2000	Year 2020
Series C (average 2.8 children)	300,406,000	392,030,000
Series D (average 2.5 children)	285,969,000	351,638,000
Series E (average 2.1 children)	264,430,000	297,746,000
Series F (average 1.8 children)	250,686,000	264,564,000

Even the high, Series C, projections are substantially lowered from two previous series now abandoned. Series A, (3.5 child-average), discontinued in 1970, projected 361 million people by 2000; while Series B (3.1 child-average), dropped in 1972, had projected 322 million.

Current demographic trends reflect anticipation of the 2.1 child average for the future, according to recent reports. Factors underlying the reduced birth rate--job opportunities, convenient birth control methods, and easier acceptance of new life styles that add up to more freedom of choice for women--appear likely to stay. However, demographic experts emphasize that the 2-child family norm does not imply an overall reduction in the numbers of people inhabiting the United States, and that it does not even imply that demographic stabilization--or "zero population growth"-- will be attained before the middle decades of the next century, even if net immigration is also reduced to zero.

The significance of the reduced birth rate will be visible, first, in the changing age-sex distribution of the labor force and the population at large; and, second, in a slower rate of population growth. If the two-child average is maintained in the next three decades, the American population will grow, but the increases will be one of 60 million people rather than the 115 million implied by a three-child average. Experts note the implications of these figures: (1) that a substantial rise in population must be anticipated even if the lower birth rate remains the norm; and (2) that an immediate return to the higher birth rate would augment this increase by more than 55 million persons within the same 30-year period.

Considering the probable distribution of future population increases among the nation's regions, a 1972 report by the U.S. Bureau of the Census speculates that by 1990 the West and the South are likely to be the big gainers in growth of population, while the regional shares of population will remain relatively unchanged--with the 16 states of the South and the District of Columbia having the largest number of residents, followed in order by the 12 Midwestern States, the 9 Northeastern States, and the 13 Western States.

The seemingly slight change in fertility rates from 2.8 to 2.1 average children per family would vary the 1990 population nationally at 251 million total under the low fertility assumption (a rise of 23% from 1970), to a projection of nearly 269 million with a high birth rate (32% increase from 1970). The following regional distributions are projected for 1990 population under the high and low fertility assumptions.

	High (2.78)	Low (2.11)
West	48.0%	37.8%
South	31.3%	22.3%
Midwest	28.7%	19.7%
Northeast	26.8%	18.7%.

Wide-ranging implications of a slower rate of population growth involves impacts on the size and composition of the labor force, resource requirements, consumption patterns, pollution levels and economic activities. However, Bureau of the Census experts note that the principal source of economic growth--investments in technology and increased productivity--will increase whether or not there are more people. This view was paralleled by the recent Presidential Study Commission on Population, which concluded that whether or not

fertility declined, average incomes would rise so much that the quality of life would change significantly. The Commission's research indicated that by the year 2000, the average family income would climb from $12,000 to $21,000 in terms of current purchasing power.

Rates of economic expansion are not solely determined by varying population growth rates, but some relationship can be observed. Experts report that although the GNP in the year 2000 under the 3-child norm would be higher--at $2.1 trillion with a projected annual growth rate of 4.0--per capita disposable income would be visibly lower than under the two-child norm, while the pressure on energy resources and raw materials would be proportionately greater. Even under the lower population projections, a doubling of GNP to nearly $2 trillion annually is anticipated by the end of the century. Furthermore, a significantly greater proportion of the enlarged total national output is expected in the form of services rather than goods. Among services, the greatest expansion is anticipated to occur in the amount of electricity required as fuel and energy, with similar rates of expansion in the availability of transportation, health care, travel and recreation.

Potential differences for general demographic and economic indicators under alternative population (Series B-2.8 child average and Series E-2.1 child average) and economic (high and low growth) assumptions have been projected by the Commission on Population Growth and the American Future. The dominant effect of shifting from a three to a two-child population projection would be an increased fraction of the population in the labor force. The

principal consequence is a higher per capita GNP and, except for the first 10 to fifteen years (when, because of greater female participation the labor force might actually be larger), a lower GNP under the Series E than under the Series B projections. The Commission indicates the relationship of these differing projections to future pollution levels:

> Per capita GNP (more accurately, per capita disposable income) can be taken as a measure of material welfare, conventionally defined. Since resource use and pollution levels are associated more with total than with per capita output levels, total GNP might be taken as a crude indicator of environmental degradation. In these terms, it is best to have a high per capita GNP but a low total GNP. This is just what we find. Compare, for example, the B-High (high population growth-high GNP growth) and the E-High (low population growth-high GNP) scenarios for the year 2000. While population size is 17 percent lower than under Series B, the labor force is only 6.6 percent less. As a consequence, GNP is 7.2 percent less and per capita GNP is 12 percent more. This pattern continues at least until the year 2020, by which time the differences between these runs become much sharper than they are in 2000.

The data further conveys the significantly higher output anticipated under high economic growth assumptions, particularly for the manufacturing sector. This indicates a direct concern for future pollution levels, given the previously mentioned EPA finding of pollution increases relative to industrial production. The Commission substantiates this concern, noting that "...in the context of 50- to 75-year projections, population growth is not the primary determinant of the level of pollution. Most environmental pollution appears to come about because of urban and industrial concentration in combination with technological developments which maximize economic growth by neglecting environmental costs."

Future water pollution levels and wastewater volumes are expected to rise dramatically if an active abatement policy is not effectively implemented. EPA and the Commission on Population Growth and the American Future report the results of a projection model based on available wastewater data and general pollution characteristics, varying the projections for Series B and Series E population growth rates and relative to both High and Low GNP increases. The 2020 projections indicate that increases are observed in all cases, but the differences resulting from combinations of high and low levels of both population and economic growth clearly indicate that economic activity exerts the dominant influence on future volumes and pollution levels of wastewater.

The Clean Water Act of 1972 may stimulate actions to decrease water use and pollution. But the accurate estimation of social and economic impacts of public policy is uncertain and will be further complicated by the role of future technologies. Projection of technology is difficult since it interrelates the uncertain influences of the private market, scientific advances and government intervention. But the need for observing technological influences is evidenced by recent observations that increased water pollution has resulted from adoption of new technologies. EPA analysts have expressed the opinion that, "The economy of the U.S. has been marked not only be a voracious absolute demand for more goods, but by a relative preference for goods whose production involves a substantial wasting of organic materials to water."

It has been stressed by major sources in the water planning literature that coordination of technology with water quality objec-

tives will significantly assist the effective implementation of clean water policy. Several recommendations by the National Academy of Sciences, Committee on Technologies and Water, to the National Water Commission reiterate the concern expressed by numerous experts in the field: (1) Technological change and impacts must be brought explicitly into water planning; (2) Technical changes likely to occur outside the immediate area of water technology but which will affect the demand for or supply of water must similarly be taken into account in water planning, as must the possibility of utilizing non-water technologies as ways of solving water-related problems; (3) Water planning must be continually reassessed to consider the benefits of new technology; (4) Water planning must have built-in flexibility; and (5) Research and development should be specifically programmed as part of a water resource plan.

6. Conclusions Related to Study Area

(a) Comparison of Alternative Projections Sources

(1) OBERS Projections

Federal water resources planning guidelines encourage the use of OBERS projections of regional economic activity for a baseline in regional plans. Developed for the U.S. Water Resources Council by the Bureau of Economic Analysis, Department of Commerce, and the Economic Research Service, Department of Agriculture, the OBERS series are designed to serve as a baseline or reference projection for the analysis of resource demands and development needs and for the evaluation of the costs, benefits and economic impact of development and management programs and projects. The Water

Resources Council states that they are in no way intended to restrict planning groups from full consideration of alternative rates and patterns of economic growth.

The relevant OBERS disaggregated units comparable to the Three Rivers Watershed study area are:

(1) Water Resources Subarea 0411-Southern Lake Erie, presenting historical and projected data for population, employment, personal income, and earnings by industry, 1950-2020. In addition to the counties in the study area (Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit), the OBERS unit includes Ashtabula County.

(2) OBE Economic Area 068-Cleveland, Ohio, presenting historical and projected data on population, personal income, earnings and employment by industry for 37 industry groups. In addition to the study area counties, the following are included in this OBERS unit: Ashtabula, Carroll, Columbiana, Coshocton, Crawford, Erie, Huron, Knox, Morrow, Richland, Stark, Tuscarawas, and Wyandot.

The following tables present the OBERS data for these water resources subarea and OBE economic area units. For comparison with alternative projection sources, several assumptions of the OBERS series should be recognized:

(1) Population growth assumes Series "C" fertility rates (2.8 average children per family).

(2) A national 4% unemployment rate, projected under the assumption that unemployment will be disproportionately distributed regionally, but the extent will diminish from past trends.

Table __1__. POPULATION, EMPLOYMENT, PERSONAL INCOME AND EARNINGS, HISTORICAL AND PROJECTED, 1950-2020: OBE Economic Area 068 - Cleveland, Ohio.

	1950	1959	1962	1968	1969	1980	1990	2000	2010	2020
POPULATION, MIDYEAR	3,153,939	3,884,002	4,005,050	4,232,812	4,236,529	4,933,400	5,652,200	6,390,800	7,228,200	8,162,300
PER CAPITA INCOME (1967$)	2,421	2,724	2,797	3,580	3,693	5,052	6,441	8,561	11,174	14,571
PER CAPITA INCOME RELATIVE (US=1.00)	1.17	1.12	1.08	1.08	1.08	1.06	1.04	1.03	1.03	1.02
TOTAL EMPLOYMENT	1,259,163	1,446,457	1,407,834			2,012,200	2,282,400	2,644,200	3,013,000	3,402,300
EMPLOYMENT/POPULATION RATIO	.40	.37	.35			.41	.40	.41	.42	.42
EARNINGS PER WORKER (1967$)	5,104	6,121	6,499			9,980	12,681	16,254	20,843	26,947
EARNINGS PER WORKER RELATIVE (US=1.00)	1.13	1.14	1.13			1.06	1.04	1.03	1.02	1.01
				IN THOUSANDS OF 1967 $						
TOTAL PERSONAL INCOME	7,637,257	10,578,460	11,201,341	15,152,810	15,645,434	24,922,400	36,407,800	54,713,900	80,769,600	118,930,300
TOTAL EARNINGS	6,426,301	8,856,488	9,150,103	12,440,422	12,984,970	20,082,400	28,942,500	42,980,700	62,802,400	91,683,000
AGRICULTURE, FORESTRY & FISHERIES	174,420	117,174	125,553	131,671	124,683	136,900	152,400	179,400	233,300	312,800
AGRICULTURE	171,630	115,527	124,260	131,035	124,111	136,100	151,300	178,100	231,700	310,900
FORESTRY & FISHERIES	2,791	1,647	1,294	638	569	(S)	(S)	(S)	(S)	(S)
MINING	28,758	31,267	37,054	48,586	53,911	70,200	84,200	103,800	126,600	155,800
METAL	312	0	541	(D)	(D)	7,700	10,300	14,100	19,000	25,500
COAL	17,186	12,659	15,154	(D)	(D)	20,100	22,700	26,200	30,000	34,100
CRUDE PETROLEUM & NATURAL GAS	3,331	6,846	6,843	19,216	20,374	24,900	29,200	34,600	40,000	46,200
NONMETALLIC, EXCEPT FUELS	7,930	11,781	14,518	13,624	12,670	17,300	21,900	28,800	37,500	49,800
CONTRACT CONSTRUCTION	388,675	538,602	496,494	810,401	910,168	1,345,300	1,913,800	2,805,800	4,051,200	5,828,500
MANUFACTURING	3,028,092	4,165,652	4,184,878	5,592,202	5,788,395	8,334,200	11,400,800	16,124,600	22,567,500	31,734,800
FOOD & KINDRED PRODUCTS	124,779	195,272	179,706	198,788	199,542	267,100	333,700	430,300	548,400	708,700
TEXTILE MILL PRODUCTS	35,401	31,199	31,230	37,018	35,727	48,800	61,900	80,600	104,000	135,900
APPAREL & OTHER FABRIC PRODUCTS	58,370	39,255	45,825	59,181	59,028	77,500	95,000	120,400	151,900	193,500
LUMBER PRODUCTS & FURNITURE	69,972	73,672	64,194	79,581	79,865	102,500	126,400	161,600	205,800	266,500
PAPER & ALLIED PRODUCTS	50,599	62,845	65,971	94,597	97,335	147,000	208,700	305,300	440,800	63[illegible],600
PRINTING & PUBLISHING	99,314	160,776	173,687	208,095	214,398	318,100	437,300	622,300	877,100	1,242,100
CHEMICALS & ALLIED PRODUCTS	116,182	172,233	182,701	256,460	269,591	410,800	582,500	849,200	1,217,200	1,741,700
PETROLEUM REFINING	34,429	40,896	39,221	51,236	56,081	69,400	84,900	106,800	133,000	169,000
PRIMARY METALS	466,739	614,028	615,988	747,343	789,059	933,000	1,092,000	1,312,300	1,559,400	1,882,300
FABRICATED METALS & ORDNANCE	417,772	601,094	642,254	825,493	847,892	1,280,400	1,775,700	2,535,300	3,568,500	5,011,600
MACHINERY, EXCLUDING ELECTRICAL		588,569	614,537	930,633	982,871	1,439,900	2,007,300	2,882,800	4,084,600	5,787,500
ELECTRICAL MACHINERY & SUPPLIES		309,323	337,307	505,966	522,999	903,900	1,413,200	2,236,900	3,437,300	5,243,400
TOTAL MACHINERY (1950 ONLY)	744,153									
MOTOR VEHICLES & EQUIPMENT	154,898	334,836	338,891	484,978	503,567	741,900	1,058,400	1,549,700	2,235,100	3,224,900
TRANS. EQUIP., EXCL. MTR. VEHS.	77,362	173,468	102,358	191,093	193,605	288,900	396,200	561,200	784,500	1,100,600
OTHER MANUFACTURING	578,124	768,195	751,608	921,742	936,827	1,304,400	1,726,800	2,369,200	3,219,100	4,389,400
TRANS., COMM., & PUBLIC UTILITIES	494,633	653,099	652,711	809,794	840,877	1,205,500	1,647,700	2,340,100	3,292,700	4,664,200
RAILROAD TRANSPORTATION	214,443	186,889	168,097	149,992	145,327	171,100	187,500	208,300	224,500	242,600
TRUCKING & WAREHOUSING	110,017	196,604	210,523	288,490	297,706	441,100	606,800	862,700	1,212,300	1,705,600
OTHER TRANSPORTATION & SERVICES	51,078	59,814	55,040	85,783	89,964	142,200	209,600	320,900	481,300	719,500
COMMUNICATIONS	70,886	102,563	109,573	152,695	168,963	251,700	369,600	557,900	825,200	1,217,700
UTILITIES (ELEC., GAS, SANITARY)	48,209	107,227	109,477	132,837	138,915	199,200	274,000	390,100	549,200	778,600
WHOLESALE & RETAIL TRADE	1,135,416	1,450,968	1,524,850	1,963,143	2,059,987	3,290,600	4,777,400	7,158,400	10,531,000	15,470,400
FINANCE, INSURANCE & REAL ESTATE	188,776	335,640	362,045	487,804	501,906	793,800	1,159,600	1,741,800	2,575,800	3,801,800
SERVICES	628,783	974,233	1,071,223	1,603,671	1,669,760	2,943,100	4,604,200	7,293,000	11,195,600	16,939,100
LODGING PLACES & PERSONAL SERV.	99,776	127,046	128,046	177,566	169,175	274,000	395,300	587,800	860,100	1,255,700
BUSINESS & REPAIR SERVICES	82,880	141,623	151,390	266,966	289,681	502,700	794,400	1,269,300	1,962,800	2,988,400
AMUSEMENT & RECREATION SERVICES	42,789	51,005	53,548	62,689	63,736	97,100	138,800	203,900	294,800	425,900
PRIVATE HOUSEHOLDS	79,375	87,504	83,571	69,044	67,651	87,600	106,400	132,100	160,800	196,900
PROFESSIONAL SERVICES	323,961	567,055	654,671	1,027,404	1,079,520	1,981,500	3,169,100	5,099,600	7,916,800	12,071,900
GOVERNMENT	358,745	589,833	695,297	993,150	1,035,285	1,962,400	3,202,000	5,233,400	8,228,300	12,775,300
CIVILIAN GOVERNMENT	333,307	550,531	654,995	946,637	988,171	1,904,500	3,127,000	5,135,800	8,102,100	12,611,300
FEDERAL GOVERNMENT	111,320	137,947	162,172	223,879	229,647	395,600	588,000	872,800	1,237,500	1,715,200
STATE & LOCAL GOVERNMENT	221,987	412,582	492,826	722,759	758,525	1,508,900	2,538,900	4,263,000	6,864,500	10,896,100
ARMED FORCES	25,439	39,304	40,299	46,519	47,113	57,800	75,000	97,500	126,200	163,900

POPULATION, APRIL 1, 1970   4,255,585

TABLE 2 . POPULATION, AND EMPLOYMENT BY INDUSTRY, HISTORICAL AND PROJECTED, 1940-2020: OBE ECONOMIC AREA 068 - CLEVELAND, OHIO

	1940	1950	1960	1966	1980	1990	2000	2010	2020
POPULATION	2,680,224	3,140,748	3,898,218	4,164,088	4,933,400	5,652,200	6,390,800	7,228,200	8,162,300
EMPLOYMENT/POPULATION RATIO	.35	.40	.37	.38	.41	.40	.41	.42	.42
TOTAL EMPLOYMENT	948,149	1,259,163	1,446,957	1,585,313	2,012,200	2,282,400	2,644,200	3,013,000	3,402,300
AGRICULTURE, FORESTRY & FISHERIES	71,239	56,979	38,862	30,324	21,000	17,400	15,500	15,100	15,100
AGRICULTURE	70,814	56,444	38,540	30,039	20,700	17,200	15,300	14,900	14,900
FORESTRY & FISHERIES	425	535	322	285	200	200	200	100	100
MINING	7,123	6,839	5,711	5,167	5,100	5,100	5,000	5,000	4,900
CONTRACT CONSTRUCTION	37,644	62,787	67,844	79,615	118,100	134,700	157,100	179,700	203,700
MANUFACTURING	362,304	524,015	606,692	656,701	755,600	823,600	917,500	1,009,800	1,104,300
FOOD & KINDRED PRODUCTS	18,394	20,761	29,039	25,853	26,000	26,200	26,500	26,600	26,600
TEXTILE MILL PRODUCTS	5,345	7,549	5,697	5,402	5,600	5,800	5,900	6,000	6,000
APPAREL & OTHER FABRIC PRODUCTS	12,213	14,257	10,944	11,863	10,700	10,100	9,400	8,900	8,400
PRINTING & PUBLISHING	16,786	22,522	31,677	36,274	40,800	43,300	47,400	51,500	55,700
CHEMICALS & ALLIED PRODUCTS	14,129	20,930	27,222	25,689	34,100	39,400	46,100	52,800	59,500
LUMBER PRODUCTS & FURNITURE	10,757	10,057	9,938	9,654	9,600	9,800	10,000	10,100	10,200
MACHINERY, ALL	59,198	112,591	132,958	156,881	204,600	238,700	282,900	327,900	374,200
MACHINERY, EXCL. ELECTRICAL		80,834	84,734	107,145	128,500	143,100	162,700	181,600	200,700
ELEC. MACHINERY & SUPPLIES		31,757	48,224	51,736	76,000	95,500	120,200	146,200	173,400
TRANSPORTATION EQUIPMENT	23,929	51,149	83,743	91,216	108,000	118,600	133,100	146,700	160,500
MOTOR VEHICLES & EQUIPMENT	18,230	34,905	61,280	74,087	84,600	91,900	102,300	111,700	121,[illegible]
TRANS. EQUIP., EX. MTR. VEHS.	5,699	16,244	22,463	17,129	23,300	26,600	30,800	35,000	39,200
OTHER MANUFACTURING	201,553	264,199	275,474	291,869	315,700	331,400	355,700	376,900	402,600
PAPER & ALLIED PRODUCTS		10,060	11,495	14,541	16,600	18,000	19,900	21,800	23,700
PETROLEUM REFINING		4,457	4,458	4,293	4,700	5,100	5,400	5,700	6,000
PRIMARY METALS		88,944	86,140	87,956	79,900	76,200	73,000	70,000	67,[illegible]
FABRICATED METALS & ORDNANCE		53,799	63,802	70,658	90,000	102,000	117,800	133,200	148,700
MISCELLANEOUS MANUFACTURING		106,939	109,579	114,421	124,300	129,900	139,500	148,100	156,700
TRANS., COMM., & PUBLIC UTILITIES	73,319	104,636	101,721	105,144	118,500	130,200	147,000	163,800	181,[illegible]
TRANSPORTATION	52,415	72,550	66,026	66,575	70,300	75,900	84,400	93,000	102,300
RAILROAD TRANSPORTATION	28,978	36,190	25,720	20,704	15,300	13,400	11,700	10,300	8,900
TRUCKING & WAREHOUSING	11,943	18,693	26,012	28,924	36,000	41,000	47,500	54,100	61,[illegible]
OTHER TRANSPORTATION SERVICES	11,494	17,667	14,294	16,947	18,900	21,400	25,000	28,500	32,200
COMMUNICATIONS	7,933	14,134	15,792	17,923	23,100	26,600	31,200	35,800	40,600
UTILITIES (ELEC.,GAS,SANITARY)	12,971	17,952	19,903	20,646	25,000	27,700	31,300	34,900	38,700
WHOLESALE & RETAIL TRADE	170,222	227,054	256,937	277,352	347,800	389,900	447,900	505,900	567,700
FINANCE, INSURANCE & REAL ESTATE	29,399	36,200	50,774	56,428	72,800	84,100	99,200	114,700	131,[illegible]
SERVICES	169,784	197,975	267,122	315,867	486,700	594,400	729,700	869,200	1,015,700
BUSINESS SERVICES	99,833	99,782	107,557	116,486	107,800	122,100	141,000	160,200	180,300
LODGING PLACES & PERS. SERV.	32,391	34,680	35,228	37,777	32,200	35,000	39,200	43,300	47,600
BUSINESS & REPAIR SERVICES	19,406	28,676	32,584	43,228	48,500	60,200	74,900	90,100	106,[illegible]
AMUSEMENT & REC. SERVICES	8,067	10,663	10,335	10,271	9,500	10,800	12,500	14,200	16,000
PRIVATE HOUSEHOLDS	39,969	25,763	29,410	25,210	17,400	15,900	14,300	12,400	10,400
PROFESSIONAL SERVICES	69,951	98,193	159,565	199,381	378,800	472,300	588,700	709,000	835,400
GOVERNMENT	27,115	42,678	51,294	58,715	86,400	102,600	124,900	149,500	177,800
CIVILIAN GOVERNMENT	26,513	40,886	49,201	56,912	84,600	100,800	123,200	147,700	176,000
ARMED FORCES	602	1,792	2,093	1,803	1,700	1,700	1,700	1,700	1,700

Source: U.S. Water Resources Council, 1972 OBERS Projections, Vol. 2, "BEA Economic Areas", pp. 140-141.

Note: The Cleveland, Ohio BEA Economic Area covers a 20-county area in Northeast Ohio, including those counties encompassing the Three Rivers Watershed.

TABLE 3. POPULATION, EMPLOYMENT, PERSONAL INCOME, AND EARNINGS BY INDUSTRY, HISTORICAL AND PROJECTED, 1950-2020: Water Resources Subarea 0411 - Southern Lake Erie.

	1950	1959	1962	1968	1969	1980	1990	2000	2010	2020
POPULATION, MIDYEAR	2,242,798	2,815,114	2,914,172	3,081,170	3,083,504	3,610,800	4,154,900	4,714,900	5,348,800	6,053,700
PER CAPITA INCOME (1967$)	2,588	2,885	2,944	3,777	3,891	5,263	6,659	8,794	11,419	14,831
PER CAPITA INCOME RELATIVE (US=1.00)	1.25	1.18	1.14	1.14	1.14	1.10	1.08	1.06	1.05	1.04
TOTAL EMPLOYMENT	913,071	1,065,603		1,254,379	1,286,993	1,486,600	1,688,300	1,958,100	2,233,200	2,523,400
EMPLOYMENT/POPULATION RATIO	.41	.38		.41	.42	.41	.41	.42	.42	.42
EARNINGS PER WORKER (1967$)	5,366	6,388		7,648	7,768	10,377	13,129	16,752	21,377	27,502
EARNINGS PER WORKER RELATIVE(US=1.00)	1.19	1.19		1.14	1.13	1.10	1.08	1.06	1.05	1.04
				IN THOUSANDS OF 1967 $						
TOTAL PERSONAL INCOME	5,804,914	8,122,065	8,579,283	11,636,660	11,999,228	19,002,300	27,667,700	41,465,100	61,077,200	89,781,500
TOTAL EARNINGS	4,899,261	6,807,527	7,023,892	9,593,401	9,996,929	15,426,100	22,166,800	32,802,100	47,739,300	69,399,100
AGRICULTURE, FORESTRY & FISHERIES	56,435	48,739	50,086	45,940	44,994	52,100	58,600	69,000	89,700	120,300
AGRICULTURE	54,930	48,077	49,548	45,622	44,718	51,700	58,100	68,400	89,000	119,400
FORESTRY & FISHERIES	1,505	662	538	319	276	(S)	(S)	(S)	(S)	(S)
MINING	7,440	8,578	11,321	20,497	23,732	34,900	44,500	57,900	7[illegible],200	95,700
METAL	312	0	541	(D)	(D)	(D)	(D)	(D)	(D)	(D)
COAL	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)	(D)
CRUDE PETROLEUM & NATURAL GAS	(D)	(D)	(D)	5,531	4,914	9,300	10,900	13,000	15,000	17,300
NONMETALLIC, EXCEPT FUELS	4,142	6,209	7,859	10,174	8,684	12,900	16,900	22,900	30,600	41,300
CONTRACT CONSTRUCTION	317,546	428,054	397,254	646,518	736,240	1,039,500	1,460,300	2,117,200	3,027,100	4,316,500
MANUFACTURING	2,331,721	3,183,427	3,176,168	4,260,575	4,376,728	6,369,700	8,746,100	12,416,900	17,450,600	24,633,300
FOOD & KINDRED PRODUCTS	95,446	139,310	124,361	132,473	132,316	165,600	197,000	243,100	297,700	371,600
TEXTILE MILL PRODUCTS	34,094	28,221	28,899	(D)	(D)	(D)	(D)	(D)	(D)	(D)
APPAREL & OTHER FABRIC PRODUCTS	53,762	33,347	41,024	46,730	43,799	60,400	71,400	87,600	107,400	134,000
LUMBER PRODUCTS & FURNITURE	(D)	(D)	(D)	48,561	(D)	(D)	(D)	(D)	(D)	(D)
PAPER & ALLIED PRODUCTS	19,515	30,688	32,214	49,619	51,263	88,300	134,300	207,100	311,400	464,100
PRINTING & PUBLISHING	77,022	127,268	132,240	166,358	170,041	256,600	357,100	512,700	727,100	1,034,600
CHEMICALS & ALLIED PRODUCTS	106,950	160,727	167,290	236,139	248,550	373,200	525,900	761,900	1,085,400	1,543,900
PETROLEUM REFINING	(D)	(D)	(D)	46,520	50,476	62,000	74,900	93,300	115,200	145,400
PRIMARY METALS	329,844	420,649	428,129	503,668	526,112	612,500	703,900	831,900	973,900	1,160,000
FABRICATED METALS & ORDNANCE	343,529	475,142	525,753	672,679	685,935	1,038,600	1,433,100	2,035,100	2,849,400	3,982,300
MACHINERY, EXCLUDING ELECTRICAL		390,092	406,549	639,965	668,073	1,073,500	1,553,000	2,295,200	3,326,600	4,799,200
ELECTRICAL MACHINERY & SUPPLIES		207,872	227,315	367,768	374,266	683,900	1,106,300	1,804,100	2,834,400	4,401,300
TOTAL MACHINERY (1950 ONLY)	513,622									
MOTOR VEHICLES & EQUIPMENT	147,774	319,212	316,467	438,329	456,572	645,000	892,600	1,269,100	1,779,100	2,498,400
TRANS. EQUIP., EXCL. MTR. VEHS.	75,319	163,602	97,865	(D)	187,426	269,700	363,400	506,800	699,600	971,900
OTHER MANUFACTURING	456,919	605,608	569,127	692,626	659,054	936,200	1,206,700	1,614,000	2,145,900	2,874,100
TRANS., COMM., & PUBLIC UTILITIES	377,740	520,522	520,353	648,526	672,940	993,400	1,372,600	1,967,100	2,787,900	3,970,700
WHOLESALE & RETAIL TRADE	894,773	1,142,546	1,215,946	1,575,002	1,653,225	2,591,700	3,737,100	5,564,500	8,138,400	11,890,500
FINANCE, INSURANCE & REAL ESTATE	156,058	273,989	301,078	406,548	417,704	656,100	956,600	1,434,500	2,118,000	3,121,600
SERVICES	503,879	781,091	861,735	1,283,528	1,336,681	2,358,200	3,684,500	5,828,000	8,933,600	13,496,000
GOVERNMENT	253,670	420,579	489,949	706,264	734,684	1,330,200	2,106,000	3,344,800	5,119,400	7,751,800
CIVILIAN GOVERNMENT	233,847	389,794	463,902	669,760	698,100	1,287,200	2,051,100	3,274,500	5,029,700	7,636,800
ARMED FORCES	19,824	30,787	26,046	36,503	36,584	42,900	54,800	70,200	89,700	115,000

POPULATION, APRIL 1, 1970 3,098,513

TABLE 4. INDEXES OF PRODUCTION FOR SELECTED INDUSTRIES, PROJECTED, 1980-2020: Water Resources Subarea 0411 - Southern Lake Erie.

(1969 EQUALS 100)

	1969	1980	1990	2000	2010	2020
MINING	100	165	216	283	363	465
METAL	100	141	198	279	387	533
COAL	100	155	215	293	383	475
CRUDE PETROLEUM & NATURAL GAS	100	198	245	303	363	433
NONMETALLIC, EXCEPT FUELS	100	141	186	252	336	453
MANUFACTURING	100	154	217	315	453	650
FOOD & KINDRED PRODUCTS	100	130	157	196	243	303
TEXTILE MILL PRODUCTS	100	138	169	212	264	335
APPAREL & OTHER FABRIC PRODUCTS	100	134	162	203	253	318
LUMBER PRODUCTS & FURNITURE	100	152	199	264	346	451
PAPER & ALLIED PRODUCTS	100	173	263	405	609	907
PRINTING & PUBLISHING	100	152	212	305	432	615
CHEMICALS & ALLIED PRODUCTS	100	163	244	373	556	824
PETROLEUM REFINING	100	122	153	196	247	315
PRIMARY METALS	100	132	151	179	209	249
FABRICATED METALS & ORDNANCE	100	154	218	317	449	632
MACHINERY, EXCLUDING ELECTRICAL	100	165	238	352	511	737
ELECTRICAL MACHINERY & SUPPLIES	100	205	359	616	1010	1602
MOTOR VEHICLES & EQUIPMENT	100	152	211	300	421	591
TRANS. EQUIP., EXCL. MTR. VEHS.	100	162	218	304	419	582
OTHER MANUFACTURING	100	132	170	227	302	404

WATER RESOURCES SUBAREA - 0411 SOUTHERN LAKE ERIE

TABLE 3. CROP AND LIVESTOCK VALUE, 1967 PRICES, AND ROUNDWOOD PRODUCTION, BY WATER RESOURCES SUBAREA, SELECTED YEARS, 1954-2020

	UNITS	1954	1959	1964	1980	2000	2020
				THOUSANDS			
CROPS 1/	DOLLARS	20809.8	19389.1	19429.5	22776.4	25838.3	30126.7
LIVESTOCK	DOLLARS	56900.9	48047.5	46954.6	36781.7	40370.6	45343.0
ROUNDWOOD 2/	CU. FT.			2000.0	9000.0	13000.0	15000.0

1/ EXCLUDES HAY AND SILAGE
2/ HISTORICAL DATA ONLY AVAILABLE FOR 1962, AND SHOWN ONLY WHEN IN EXCESS OF 1 MILLION CU. FT.

Source: U.S. Water Resources Council, 1972 OBERS Projections, Vol. 3, "Water Resources Regions", pp. 132-3.

Note: The Southern Lake Erie Subarea includes Ashtabula County in addition to those 7 counties of the Three Rivers Watershed.

(3) Most factors that have influenced historical shifts in regional "export" industry location will continue into the future with varying degrees of intensity.

(4) Trends toward economic area self-sufficiency in local industries will continue.

(5) Workers will migrate to areas of economic opportunities and away from slow-growth or declining areas.

(6) Regional earnings per worker and income per capita will continue to converge toward the national average and regional employment/population ratios will tend to move toward the national ratio.

The WRC defines the OBERS series as "baseline projections of the best estimate of what can be expected to materialize if there are no policy or program changes of an unusual and unforseen nature or magnitude in the factors which have been changing over time and which are expected to continue on course in the future. They are in no sense meant to represent a goal, and they should not constrain the planner in considering alternative levels of growth which might be achieved through more or less resource development." In using the OBERS series, the WRC cautions that long range projections are less reliable than those for short periods, and that small aggregate unit projections are less reliable than those of large magnitude. Furthermore, projections of water use are less reliable than are projections of economic activity. WRD notes that "future water use depends not only on the projected economic activity, but in addition, on projected changes in the technology of water use and the cost of water relative to its substitutes. Quantification of both of these variables is subject to significant degrees of uncertainty."

In using the OBERS series for regional assessment of future demands for water and related land resources, the WRC suggests that realistic estimates may be derived by a "determination of economic demand schedules for water based on analysis of the economics of its use as influenced by changing technology and shifting values in various uses. The planner may vary the projections to test the sensitivity of plans to different levels of economic activity and to introduce flexibility in the plan in order to accommodate to various future conditions."

(2) Comparisons of Population Projection Sources

Concerning the population projections used for both municipal and industrial wastewater projections in the alternative plans, a comparison to alternative projections of the watershed's population reveals significant differences. Table 5 presents data on population projections from both federal and regional sources for somewhat larger units encompassing the Three Rivers Watershed. The estimates of the study area design projections and the OBERS series are roughly equal through the year 2000, while the design estimates indicate a more leveled growth during 2000-2020. It should be recognized that the OBERS series is based on a 2.8 child-family assumption, a decision based on U.S. Census expectations of the late 1960's. More recent documentation, as previously analyzed in this report, appears to justify the current Census anticipation of a lower future growth rate based on observable trends from the 3 to 2 child-average family. The U.S. Census projections for Ohio are presented in Table 5 for both Series C (2.8 average children/family) and Series E (2.1 average)

TABLE 5 COMPARISON OF STUDY AREA POPULATION PROJECTIONS
ALTERNATE SOURCES

Projection Unit and Source[+]	1970 Population Base*	% increase from 1970 Population** 1980	1990	2000	2010	2020
1. U.S. Census-Ohio						
a.) Series I-C	10,652,000	12.5%	27.8%			
b.) Series III-C	10,652,000	13.4%	29.2%			
c.) Series I-E	10,652,000	9.6%	19.2%			
d.) Series III-E	10,652,000	10.5%	20.5%			
2. OBERS						
a.) Ohio	3,098,513	18.1%	37.1%	56.3%	78.6%	1.04%
b.) Southern Lake Erie Water Resources Subarea	10,652,017	16.5%	34.1%	52.2%	75.5%	95.4%
c.) Cleveland, Ohio Economic Area	4,255,585	15.9%	32.8%	50.2%	69.8%	91.8%
3. Batelle Model 3 Rivers Watershed Study Area	2,746,845	14.02%	38.9%	57.4%	69.6%	76.6%
4. NOACA N.E. Ohio 5-County Area	3,000,276	8.3%	17.8%	25.8%		
5. NOUS (N.E. Ohio)						
a.) Optimistic	3,098,507	14.4%	29.6%	44.9%		
b.) Conservative		9.4%	19.7%	31.1%		

*All 1970 population figures are based on U.S. Bureau of the Census, 1970, with the exception of NOUS (4.).

** The sources differed among future projection dates· the data presents the projections for the longest range provided by each source.

Table 5 (Continued).

+Sources of projections and geographic area covered in each are as follows:

1. Source: U.S. Department of Commerce, Bureau of the Census Social and Economic Statistics Administration, Current Population Reports: Population Estimates and Projections (Series P-25, No. 477), March 1972. Table 1: "Projections of the Population of States, 1975-1990, and Census Populations, 1960 and 1970", pp. 4-5.
   Geographic Area Covered: State of Ohio.
   a.) Fertility assumption "C-Series" (2.8 average children per family); Internal Migration assumption "I-Series".
   b.) Fertility assumption "C-Series"; Internal Migration assumption "III-Series".
   c.) Fertility assumption "E-Series" (2.1 average children per family); Internal Migration assumption "I-Series".
   d.) Fertility assumption "E-series"; Internal Migration assumption "III-Series".

2. Source: U.S. Water Resources Council, 1972 OBERS Projections: Regional Economic Activity in the U.S. by Economic Area, Water Resources Region and Subarea, and State, Historical and Projected--1929-2020 (September, 1972).
   Geographic Area Covered:
   a.) State of Ohio
   b.) Southern Lake Erie Water Resources Subarea, as delineated by the Water Resources Council in July, 1970; The area encompasses the following 8 counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit.
   c.) Cleveland, Ohio Economic Area, one of 173 functional economic areas nationally delineated by the Bureau of Economic Analysis; the area encompasses the following 20 counties: Ashtabula, Carroll, Columbiana, Coshocton, Crawford, Cuyahoga, Erie, Geauga, Huron, Knox, Lake, Lorain, Medina, Morrow, Portage, Richland, Stark, Summit, Tuscarawas, and Wyandot

3. Source: Havens and Emerson, Ltd., Consulting Engineers, Survey Scope Study for Three Rivers Watershed Wastewater Management Program, Phase I, Part A (May, 1972).
   Geographic Area Covered: Three Rivers Watershed, Northeast Ohio.

4. Northeast Ohio Areawide Coordinating Agency (NOACA), Population Forecast 1970-2000 (September, 1972).
   Geographic Area Covered: The 7-County Northeast Ohio Region (Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit Counties).

5. The Northern Ohio Urban System Research Project, Population, Employment and Income Forecasts (Nous Research Project Report No. 12), Prepared by Doxiadis Associatios Int., for The East Ohio Gas Company, The Ohio Bell Company and The Higbee Company, Cleveland, Ohio (March, 1972).
   Geographic Area Covered: Ashtabula, Cuyahoga, Geauga, Medina, Lake, Lorain, Portage and Summit Counties.

varied for alternative internal migration assumptions, demonstrating the significant decrease in 1990 population growth obtained from use of the lower fertility rate. Furthermore, an extension of projections to the long-range 2020 future would indicate a significant leveling of population growth.

NOACA and NOUS projections provide a regional source of comparisons. The Northern Ohio Urban Research System (NOUS) projections are based on examination of historical and recent patterns of regional demographic and economic growth, recognizing the competitive losses the study area has suffered in recent years. NOUS projections vary from optimistic assumptions of the Northeast Ohio region's ability to recover from its declining growth rates to the conservative assumption of a continuation of current trends; however, even the optimistic assumptions indicate lower population projections than the study area's design estimates. The Northeast Ohio Areawide Coordinating Agency (NOACA) indicates drastically lower population growth expectations. Considering that these represent the expectations of the region's planning officials, serious attention should be given the observed differences from the design projections.

Examination of the projections of individual county units demonstrates further contrasts to the high growth estimates of the study area's design projections, relative to regional and local planners' expectations. Table 6 shows that all counties in the Three Rivers Watershed Area anticipate significantly lower population growth according to regional planning sources than that indicated by the design projections.

TABLE 6 Comparison of Study Area County Design Population Projections With Local Sources*

1. Cuyahoga County

Projection Source	1970	1980	1990	2000	2020
Design Projections	1,721,404	1,842,070 (7.0%)	2,193,050 (27.3%)	2,393,720 (39.1%)	2,523,000 (46.5%)
NOACA	1,721,300	1,724,900 (0.2%)	1,746,600 (1.5%)	1,741,000 (1.1%)	
Cuy. Cty. Reg. Plan. Comm.	1,721,300	1,723,000 (0.1%)	1,742,000 (1.2%)		
CEI (Clev. Elec. Illum. Co.)	1,721,300	1,783,000 (3.6%)			

2. Geauga County

Projection Source	1970	1980	1990	2000	2020
Design Projections	63,125	90,300 (42.9%)	126,400 (100.7%)	166,900 (164.4%)	230,600 (266%)
NOACA	62,977	86,100 (36.7%)	112,000 (77.8%)	140,800 (123.6%)	
Geauga Cty. Plan. Comm.	62,977	85,500 (35.8%)	112,600 (78.8%)		
CEI (Clev. Elec. Illum. Co.)	62,977	84,300 (33.8%)			

3. Lake County

Projection Source	1970	1980	1990	2000	2020
Design Projections	197,154	268,600 (36.2%)	369,200 (87.2%)	464,100 (135.4%)	600,300 (204.4%)
NOACA	197,200	266,500 (35.1%)	318,700 (61.6%)	348,000 (76.4%)	
Lake Cty. Plan. Comm.	197,200	263,050 (33.4%)	318,400 (61.4%)		
CEI (Clev. Elec. Illum. Co.)	197,200	250,400 (26.9%)			

TABLE 6 (Cont.)

4. Lorain County

Projection Source	1970	1980	1990	2000	2020
Design Projection	7,003	7,500 (7.1%)	8,000 (14.2%)	8,300 (18.5%)	8,200 (17.1%)
NOACA	256,843	302,300 (17.7%)	360,100 (40.2%)	427,200 (66.3%)	

5. Medina County

Projection Source	1970	1980	1990	2000	2020
Design Projections	82,583	120,700 (46.1%)	161,400 (95.1%)	195,400 (136.6%)	256,100 (209.6%)
NOACA	82,717	111,100 (34.3%)	143,100 (73.0%)	175,900 (112.6%)	
Tri-County RPC	82,717	112,450 (35.9%)	146,200 (76.7%)	178,600 (115.9%)	236,500 (185.9%)

6. Portage County

Projection Source	1970	1980	1990	2000	2020
Design Projections	123,078	166,400 (35.2%)	221,600 (76.0%)	279,800 (127.3%)	357,600 (184.1%)
NOACA	125,868	160,600 (27.6%)	197,900 (57.2%)	234,700 (86.5%)	
Tri-County RPC	125,868	165,850 (31.8%)	206,700 (64.2%)	244,350 (94.4%)	288,850 (129.4%)

7. Summit County

Projection Source	1970	1980	1990	2000	2020
Design Projections	552,498	640,800 (23.2%)	737,700 (33.3%)	814,900 (47.4%)	875,300 (58.2%)
NOACA	553,371	599,400 (8.3%)	655,900 (18.5%)	706,500 (27.7%)	
Tri-County RPC	553,371	618,550 (11.8%)	673,150 (21.6%)	721,800 (30.6%)	798,700 (44.3%)

TABLE 6 (Cont.)

* Projections were obtained form the following source references:

1. Design Projections: Havens and Emerson, Ltd., Consulting Engineers, Survey Scope Study for Three Rivers Watershed Wastewater Management Program, Phase I, Part A (May, 1972). Geographic Area Covered: Three Rivers Watershed, Northeast Ohio. NOTE: 1970 Census base population figures cover only that area of the county encompassed within boundaries of the Three Rivers Watershed.

2. Northeast Ohio Areawide Coordinating Agency (NOACA) Population Forecast 1970-2000 (September, 1972).

3. Cuyahoga County Regional Planning Commission, 1970-1990 population projections as reported in: "City Facing 33% Loss in Population," The Cleveland Plain Dealer, June 28, 1972.

4. Cleveland Electric Illuminating Company, Marketing Services Department, as reported in: "Population is Still Growing, Report Says," The Cleveland Plain Dealer, August 2, 1972.

5. Geauga County Planning Commission, Past and Projected Population for Geauga County Ohio, 1940-1990 (Prepared from 1970 Census figures).

6. Lake County Planning Commission, Census and Projected Population by Political Subdivision, 1970-1990 (Preliminary 1972 figures).

7. Tri-County Regional Planning Commission (Summit, Portage and Medina Counties), Population Forecast, 1970-2020 (Prepared July, 1972).

(3) Projections of Economic Activity

The projections of employment for the alternative plans have taken account of the trends observed in recent decades, and may be compared with those economic indicators provided by the OBERS series which disaggregate regional projections from the national totals. Detailed comparisons of that data will not be presented here, although some general considerations can be made of the employment projections in light of the previous analyses of the study area's "Regional Characteristics" and "Regional Objectives" provided in this report. The shift in industrial composition of the Cleveland-Akron metropolitan area from durable to non-durable manufacturing, in addition to anticipations of more service industry development, has not yet been stabilized in the area's economic base. Consequently, the study area may be characterized as presently fluctuating in a state of transition relative to changes in industrial composition and employment opportunities. The future projection of economic indicators is therefore subject to a range of uncertainties which complicate the accuracy of current forecasts.

(4) Additional Consideration of the Wastewater Projection Assumptions

The domestic and municipal projections for the study area's alternative plans have assumed additional factors related to water use patterns which may be considered against the framework of potential future influences. While the design projections acknowledged potential changes in domestic water-using technologies, it was not assumed that future adoption was probable. Also, land use projections were given some recognition in relation to municipal wastewater

projections, but the land use composition maps used for projections may not accurately provide the density and housing type detail necessary to firmly establish future municipal water uses and treatment needs. In analyzing the municipal wastewater projections, the future influences discussed in the previous section on general trends in municipal water uses warrant consideration, particularly the potential influences of public policy and environmental attitudes on future water use practices.

The industrial wastewater estimates provided for the study area have considered some trends of changing water use practices relative to advanced technologies and conserving management practices. However, the crucial role of cost impacts resulting from federal clean water policy have not yet been fully realized in industrial responses. While the design projections assumed a 14% decrease in 1990 wasteloads attributable to industry's abatement programs, the actual future industrial wastewaters may be further reduced by substantial rates if considerations of the varying strategies previously discussed under industrial water uses are implemented. Furthermore, the role of technology in industrial wastewater projections is complicated; depending on incentives provided industry, more or less water-using and pollution-producing technologies may be adopted. The role of public policy is probably the most significant determinant, and the impacts of clean water policy have not yet been fully realized for estimating future industrial responses.

(5) Conclusions

Evaluation of the study area design projections has indicated a critical concern for their accuracy. Specific data contrasting alternative population projection sources casts doubt on the high estimates of the design projections. Furthermore, uncertain economic conditions in the region cloud the accuracy of employment projections. In addition to these criticisms, the use of 2020 wastewater projections for the design of wastewater management systems warrants serious criticism, due to the yet unforeseen repercussion of federal clean water policy, as well as a range of other uncertainties which may impact water use and related wastewater treatment requirements.

In the face of these uncertainties, we must conclude that the projection of wastewater loads for the several alternate plans, are subject to question, with the possibility of significant error on the high side.

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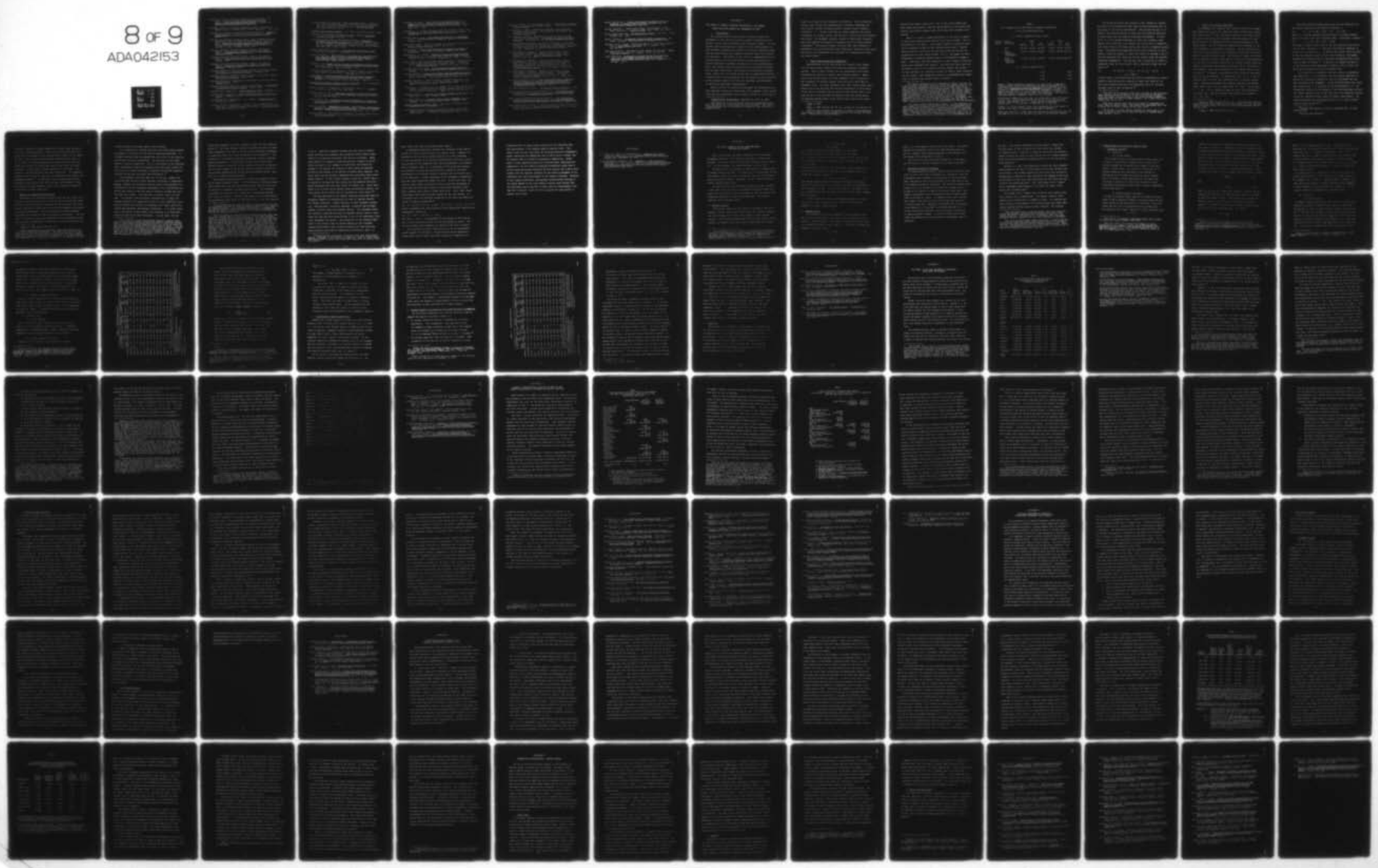

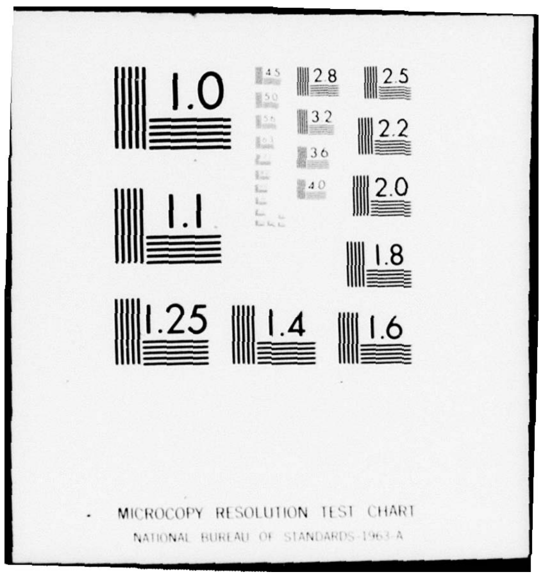
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Attachment D

THE IMPACT OF FEDERAL FINANCING PROVISIONS IN THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

1. Introduction

The recently enacted Federal Water Pollution Control Act Amendments of 1972 contain provisions capable of generating inefficient choices among alternative waste treatment systems. The new federal financing arrangements coupled with the encouragement of land treatment technology may result in localities choosing systems that are significantly more expensive than the least cost alternative available. The purpose of this note is to demonstrate the potential impact of the new legislation by using data relating to selected wastewater treatment alternatives in the Cleveland-Akron area. The federal share of project costs is described in section 202 (a) which states that, "The amount of any grant for treatment works...shall be 75 per centum of the cost of construction thereof..."[1] In other words, local governments will be required to pay 25 percent of the original capital costs plus all operation and maintenance (O and M) and replacement expenditures.[2]

Section 108 (d) (2) explicitly encourages the consideration of land treatment systems by stating that, "This program...shall provide local and state governments with a range of choice as to the type of

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[1] Congressional Record-House, September 28, 1972, p. 8865.

[2] Consideration of the provisions relating to industrial user fees will result in a modification of this statement. The implications emanating from the treatment of industrial user fees will be examined below.

system to be used for the treatment of wastewater. These alternative systems shall include both advanced waste treatment technology and land disposal systems including aerated treatment-spray irrigation technology..."[3] Studies following the format suggested are already in progress in Chicago, Boston, San Francisco, Detroit and the Cleveland-Akron area. The amendment contains a number of additional statements which were apparently designed to encourage the use of land treatment technology.[4] Preliminary evidence indicates that land treatment of wastewater will prove technically and economically feasible in many areas and thus it will undoubtedly be considered for widespread use within the United States.

2. Impact Upon Residential Communities

Implementation of this legislation will require local communities to choose among a number of alternative wastewater treatment systems. Some of these systems will use conventional water based technology and others will employ land treatment methods. Regardless of the system chosen, the local community will be required to pay 25 percent of original capital costs plus all O and M and replacement costs. The local community will, other things being equal,[5] choose the system requiring the smallest expenditure of local funds. If the ratio of original capital costs to total system costs is the same for all of the available alternatives then the system chosen on financial grounds alone by the locality will also be the system

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[3]Ibid, p. 8863.

[4]Ibid, p. 8865 section 201 (d) (1), section 201 (e) and 201 (f).

[5]Each of these systems will generate a number of environmental and ecological effects which cannot accurately be included in system costs. This point is discussed below.

involving the lowest total costs. But if this ratio differs markedly among alternatives, then the system chosen by the locality may involve significantly higher total costs than other available alternatives.

There is, in fact, a marked difference in the ratio of capital to total costs between water based and land based systems. This is illustrated by the Table 1 cost figures relating to selected alternative treatment systems for the Cleveland-Akron area.[6] Capital costs are 66% of total costs for the land system and 43% and 35% respectively for water based systems 2 and 3. The impact of these differences in relative capital costs is illustrated in columns 3 and 6. When total costs are considered, system 3 shows a 39 million dollar cost advantage over system 1. But when only local costs are considered, system 1 is 14 million dollars cheaper than system 3. In this instance, the locality, if given the choice, would certainly opt for system 1 even though this system is considerably more expensive to construct and maintain than is system 3.[7]

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[6]The annual comparative costs presented in table 1 are not, in a strict sense, the proper costs to use in the present context. Systems should be compared on the basis of the present value of all costs incurred throughout the planning period. The bias in the selection process will then occur if the ratio of the present value of original capital costs to the present value of total costs differs among alternatives. The precise timing of cost outlays has not yet been incorporated into the cost estimates and thus the annual comparative costs are the only figures available. Preliminary information on the timing of cost outlays indicates that the use of Table 1 data will not result in an overstatement of the bias generated

[7]The three systems summarized in Table 1 do not represent the total range of alternatives available for the Cleveland-Akron area. They were chosen specifically to illustrate the potential problems associated with the new federal financing provisions. A land treatment system entailing lower total costs (141,000,000 than system 3 in Table 1 has been tentatively proposed but important aspects of the technology involved have yet to be proven on an experimental basis.

TABLE 1

Cost Comparisons For Wastewater Treatment Alternatives

In The Cleveland-Akron Area

A.) Annual Comparative Costs (,000)[1]

System Number	System Technology	Total 1 Capital	 2 OM	 3 Total	Local 4[2] Capital	 5 OM	 6 Total
1	Land	120,900	62,300	183,200	30,225	62,300	92,525
2	Water (Advanced Biological)	64,200	84,300	148,500	16,050	84,300	100,350
3.	Water (Physical Chemical)	50,500	94,100	144,600	12,625	94,100	106,725

B.) Relative System Costs[3]

System Number				3 Total			6 Total
1				1.267			1.000
2				1.027			1.085
3				1.000			1.153

SOURCE: Wright-McLaughlin Engineers U.S. Army Corps of Engineers Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study Formulation Technical Appendix Development of Array of Alternative Regional Plans for Wastewater Management, November, 1972 Summary Section Table 4. All systems were designed to achieve the same water quality standards for year 2020 wasteloads. The costs of treating separate stormwater runoff are not included.

[1]Total annual comparative cost (col. 3) is the sum of year 2020 O and M costs (col. 2) plus depreciation and interest (7%) on year 2020 capital requirements (col. 1). Total capital requirements for the systems were: 1) $1,614,400; 2) $838,600 and 3) $603,300.

[2]Column 4 is 25% of column 1 since this represents the local share of capital costs under the proposed financing arrangements.

[3]Based upon section A. Each figure was derived by dividing the cost for the plan by the cost for the low cost plan in the specific category.

The 39 million dollar bias present in this example is, however, far short of the maximum bias that might be generated given the cost structures of the various alternatives. The maximum bias may be defined as the maximum increase in total cost that could be generated by local choice and the proposed financing arrangements. In other words, it is the maximum difference in total cost between a high capital cost system and a low capital cost system that is compatible with local choice of the high capital cost system on financial grounds alone. The maximum bias among the three systems shown may be calculated by using the capital to total cost ratios for systems 1 and 3,[8] and then equating local costs for the two systems under the proposed financing arrangements. This has been done in equation (1) where T_1 represents total cost for system 1 and T_3 represents total cost for system 3:[9]

$$(1) \qquad .25\ (.66\ T_1) + .33\ T_1 = .25\ (.35\ T_3) + .65\ T_3$$

$$\therefore \quad T_1 = 1.490\ T_3$$

In other words, the maximum bias that could be generated in a choice between a land system with a capital to total cost ratio of .66 and a water based system with a corresponding ratio of .35 would increase costs by about 49 percent.[10]

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[8]The size of the potential bias will increase as the difference among systems betwen the capital to total cost ratios increases. Thus, the largest potential bias in the Cleveland-Akron example is associated with the choice between systems 1 and 3 where this ratio ranges from .66 to .35.

[9]The first term on each side of the equation represents the local share of capital costs. The second term represents the O and M costs, all of which is borne at the local level.

[10]A similar, but much smaller maximum bias amounting to just under 9% of total costs exists when the choice is between water based systems 2 and 3.

3. Impact of Industrial User Fees

The amendment also requires that localities place user charges upon industries to cover the industrial share of both total capital and O and M costs.[11] Thus, the local industries will clearly favor the lowest cost alternative available since the percent of total costs allocable to industries will be the same regardless of the system chosen. But the situation confronting the remainder of the local community is considerably different. The non-industrial sector of the local community is not obligated to pay back the federal share of original capital costs. The recovery of funds in this manner is, however, limited to the smaller of the two following amounts: (1) the sum of the local contribution to original capital costs and expected replacement and expansion expenses; and (2) 50 percent of the industrial user fees attributable to the federal share of capital costs.[12] In general, the effective limit should be associated with the second condition. To demonstrate this, let α = the industrial share of total local wasteload and K = original capital costs. Ignoring replacement and expansion expenses, the amounts under limits 1 and 2 will be equal when $.5(\alpha\ .75K) = .25K$ or where $\alpha = .666$. If the industrial share of total local wasteload is less than .666, then the effective constraint will be number 2, i.e., $5(\alpha\ .75K)$.

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[11] Ibid, p. 8866 section 204 (b) (1). Industries will thus be required to pay their share of (1) O and M costs, (2) the 25% local share of capital costs, and (3) the 75% federal government share of capital costs.

[12] Ibid, p. 8866 section 204 (b) (3).

The total financial burden placed upon the non-industrial sector of the locality will be given by expression 2:

(2) $(1 - \alpha)(O + M) + .25(1 - \alpha)K - .5(\alpha\ .75K)$

where O + M denotes operation and maintenance (including replacement) costs and α and K are as defined above, Expression 2 reduces to

(3) $(1 - \alpha)(O + M) + .25K - \alpha.625K$

The range of capital costs borne by the non-industrial local sector will be from .25K when $\alpha = 0$ (the purely residential community of section I) to 0 when $\alpha \geqslant .4$. If none of the capital costs are borne by the non-industrial sector of the local community, the maximum possible bias introduced by the financing arrangements would raise costs by about 97 percent.[13] In general, the higher the value of α, the less will be the importance of capital costs to local residents and the greater will be the potential bias.

It is difficult to estimate, even very crudely, a representative value for α. To be reliable, such an estimate would have to predict the response of industry to the new regulations and user fees contained in the amendment. In the Cleveland-Akron area, based upon volume alone, α is currently in the neighborhood of .2. Considerations relating to the strength of the wasteload might increase this figure somewhat, but, on the other hand, the industrial response to the new regulations might lower the figure significantly. The maximum potential bias associated with an α of .2 would increase costs by about 68 percent.[14]

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[13] Derived from equation 1 with 0.0 replacing the .25 local capital share.

[14] Derived from equation 1.

Industries located in highly industrialized areas might be placed in a very difficult position. Their only defense would seem to be in the form of an appeal to the voting public either; (1) to reduce the size of the α used in assessing the industrial user fees, or (2) to adopt a cosmopolitan point of view and select the low cost system even though this system may entail higher costs for local residents. Neither form of appeal appears very promising. The level of α can be determined with some objectivity. The amendments actually require that the value of α be approved by the federal program administrator.[15] In addition, local residents may be quite hesitant to bear higher taxes and user fees, particularly if they feel that the higher industrial costs will be passed on primarily to consumers in other localities.

3. Summary and Suggested Modifications

The practice of subsidizing capital costs but not O and M costs has not, in the past given rise to the type of bias discussed above. Once the level of wastewater treatment was decided upon, the system choices available to localities did not differ markedly with respect to capital requirements. But the development of land treatment technology has altered the choice structure significantly. The high ratio of capital to total costs exhibited by land treatment systems will make them "artificially" attractive to localities who bear only

[15] Ibid, p. 8866 section 204 (b) (1).

[16] Land treatment may significantly reduce the internal treatment costs imposed upon industries. The feasibility of such costs reductions has not yet been clearly established but they do appear potentially capable of offsetting a large part of the anti-industry bias contained in the financing arrangements. See footnote 19 infra.

a small portion of the high capital costs involved.

It is difficult to estimate the extra cost which would actually be generate/ in practice by the federal financing provisions. It is highly unlikely that the maximum bias will occur in the selection between any two given alternatives. The increase in cost could, however, be quite significant. This is illustrated by the Cleveland-Akron alternatives where the financing provisions point toward the selection of a system involving a 27 percent ($39,000,000 annually) increase in cost over the lower cost alternative.[17]

The preceeding discussion does not, in any way, support the conclusion that the use of land treatment technology is inadvisable per se. Because the discussion centered around the potential bias introduced by the new financing arrangements, the illustrations presented were chosen so that the capital intensive systems were also the high cost systems. This does not, of course, have to be the case. The economic (and ecological) advisability of using land treatment methods will depend upon a host of local conditions including the amounts and location of acceptable soil types, land costs, climate and hydrologic and geologic conditions. It is quite likely that in many parts of the country land technology will prove more economical than water based technology. In such cases, the new

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[17] In a period of rapid technological advance, another objection may be directed toward the proposed federal financing arrangements. These financing arrangements provide a strong incentive for the construction of systems entailing high capital costs. Such systems are relatively inflexible since they cannot respond as rapidly as can low capital cost systems to technological improvement. We cannot be sure that rapid technological progress will be made in this area, but our heightened national concern over water quality problems does point in this direction.

financing arrangements will not introduce a bias into the selection process.[18] But there remains a distinct possibility that the financing arrangements will lead to the use of land treatment technology in localities where less costly alternatives are available.[19] The criticism of the proposed financing arrangements leaves an obvious question unanswered. If the public decides that a significant federal subsidy is justified on the grounds of benefits accruing to the non-local segment of the nation, then how can this subsidy be given without generating the inefficiencies discussed above? There seem to be a number of possibilities.

The simplest solution would be to remove the element of local choice among treatment systems. The Environmental Protection Agency (EPA) would choose the low cost system and the locality would then be required to implement this particular system. This obviously eliminates the possibility of a high cost system being selected over a low cost system. However, there appear to be strong reasons for maintaining local choice in this matter if it is at all possible

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[18]A different type of bias may result if the benefits accruing to individuals outside the locality either exceeds or falls short of the federal subsidy. Considerations relating to the appropriate portion of project costs to be borne by the federal government are beyond the scope of this note.

[19]At this point in time our lack of experience with large land treatment systems makes it very difficult to cost them properly. There are a number of potentially important cost offsets associated with the Cleveland-Akron area land treatment systems that have not been incorporated into the Table 1 figures. Among these are: (1) the use of effluent water for cooling purposes in the electric power industry. This could produce an annual revenue of 3 to 6 million dollars. (2) the revenue from agricultural output grown on irrigated lands--this might, in some cases, amount to $5 million per year, and (3) reduced costs associated with the industrial pretreatment of wastewater--the potential saving from this source ranges from $5 million to $30 million annually. Further consideration of and experimentation with land treatment technology definitely seems to be warranted.

to do so. Different treatment systems will give rise to significantly different environmental and ecological effects which simply cannot be incorporated accurately into the cost estimates. Among these effects are changes in land use patterns, changes in terrestrial and aquatic life, changes in stream flow characteristics, changes in the quality and location of water based recreational activities and changes in the quality of ground water supplies. The local choice option provides a mechanism for evaluating these differential effects. If the locality chooses a high cost system, then it is implicitly stating that this system has environmental and ecological advantages that more than offset its higher cost. Since there seems to be no other way to measure these non-pecuniary effects, the local choice option should only be discarded as a last resort.[20]

The bias generated by the federal financing provisions might be mitigated somewhat by manipulating the types of capital eligible for federal subsidies. Capital peculiar to land treatment systems, e.g., land purchase, relocation expenses, irrigation and drainage capital, could be denied the federal subsidy. This procedure would not succeed in equating the ratio of eligible capital costs to total costs for land and water based systems in all of the individual localities throughout the nation. The variability in the relative importance of the various types of capital making up land treatment systems would prevent such a general equalization from occurring. Administration would thus be cumbersome and difficult, and it is

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[20]Localities may also place a positive value upon local choice *per se*. Although it is difficult to quantify, there is little doubt that individuals do place some value upon being able to control their own destiny.

quite likely that much inefficiency would remain.

A preferable alternative involves the extension of the federal subsidy to O and M costs as well as to capital costs. Complete elimination of the bias would further require one of the following: (1) the elimination of the provision allowing the locality to retain some portion of the industrial user fees attributable to the federal share of capital costs, or (2) extension of the provision allowing the locality to retain some portion of the industrial user fees attributable to the federal share of capital costs to O and M costs on the same basis. Either adjustment in the treatment of industrial user fees would completely remove the bias. In the first case, the locality would simply be required to pay a specified percentage of total costs and they would receive no offsetting revenues of any kind to defray their share of these total costs. Thus, other things being equal, they would obviously choose the low cost system. In the second case, the financial obligation of the local non-industrial sector is given by expression 4:

(4) $(1 - \alpha) S(O + M) + (1 - \alpha) SK - .5\alpha (1 - S) K - .5\alpha (1 - S) (O + M)$

where S represents the local portion of both capital and O and M costs. Expression 4 reduces to:

(5) $(S - .5\alpha S - .5\alpha) [K + (O + M)]$

The term $S - .5\alpha S - .5\alpha$ represents the percentage of both capital and O and M costs borne locally by the non-industrial sector. The low cost system would therefore, be chosen by the local residents.

The distributive effects associated with the two adjustments would, however, be different. Highly industrialized communities would suffer larger losses than would residential communities if

localities were no longer given a portion of the industrial user fees attributable to the federal share of capital costs. This results from the fact that under the existing financial arrangements highly industrialized communities are in effect given a larger capital subsidy than are primarily residential communities. Unless there is some compelling reason for favoring highly industrialized communities, the best federal financing arrangements would seem to involve equal percentage subsidies for both capital and O and M costs coupled with the complete retention by the federal government of all industrial user fees attributable to the federal subsidies. Needless to say, budget constraints, and perhaps considerations relating to the proper amount of the total federal subsidy would dictate that the percentage subsidy applied to total costs be significantly less than the 75 percent figure currently proposed for application to capital costs alone.

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Attachment E

THE FISCAL CAPACITY OF THE CLEVELAND-AKRON METROPOLITAN REGION

One of the foremost problems confronted by the wastewater management authority is to find ways and means to finance the program. Three main sources of financing available to the counties are: (1) Tax Revenues, (2) Nontax Revenues, and (3) Debt.

The major source of revenue are taxes which are supplemented by nontax revenues and debt. The capacity of raising money through debt depends mainly upon the local wealth, the main constituent of which are property values. Therefore, in this report we will be mainly concerned with taxes.

In order to assess the financing capability of the counties in the study area, as well as of counties outside the study area which will also benefit from the program, we have to evaluate the financing capability in terms of two measures: (A) Revenue capacity and (B) Revenue effort.

A. Revenue Capacity

The revenue capacity of the county is defined as the total amount of revenue that would result within the county by applying the state average rate of the varied kinds of local revenue sources. The following formula which was used to estimate revenue capacity of property taxes will help us understand this measure.

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* The methodology of this report is based upon the methodology developed in Measuring the Fiscal Capacity and Effort of State and Local Areas, Information Report, Advisory Commission on Intergovernmental Relations, Washington, D.C., March, 1971. Report prepared by Dr. Vijay Mathur, Cleveland State University.

$$r_i = \Sigma_j T_{ij}/\Sigma_j M_{ij} \quad (1)$$

$$C_{ij} = r_i M_{ij} \quad (2)$$

T_{ij} is taxes levied on ith type property in jth county.

M_{ij} is market value of ith type property in jth county

r_i is average tax rate on ith type property in the State of Ohio.

C_{ij} is revenue capacity of property taxes levied on ith type in jth county.

After obtaining r_i for each type of property using equation (1), we can obtain the total revenue capacity of property taxes (C_j) in the jth county as follows:

$$C_j = \Sigma_i C_{ij} = \Sigma_i r_i M_{ij} \quad (3)$$

This revenue capacity measure indicates the amount of revenue which the county could have raised had it taxed the local property at the average tax rate. Note we are using here the State of Ohio as a standard which does not deny us the use of any other standard, eg., the nation

In this report we will generate revenue capacity of income tax, of sales tax, of property taxes and of all these taxes combined; a kind of summary measure.

B. Revenue Effort

To evaluate the financing capability of the county we also have to look at the effort that these areas are making to raise revenue. Revenue effort is the actual revenue from a given source as a proportion of the revenue capacity. In symbols following the example of property taxes:

$$E_j = T_j/C_j \quad (4)$$

where T_j is total property taxes levied in jth county. The effort measures are obtained for each of the taxes mentioned above, as well as a summary effort measure generated to gain insights into the average effort being made by counties.

The fiscal year 1970-71 was used because this is the latest year for which all the data relevant to this study is available.

C. Overview of Current Tax Revenues

The data presented in Table I indicates that in the fiscal year (1970-71) out of the total tax revenue (i.e. income tax, sales tax and property taxes combined), over 80 percent of the tax revenue comes from property taxes in the counties of the study area as well as in counties outside the study area. The income tax revenue varies between 1.9 to 14.7 percent in the study area counties, and 6.3 percent to 14.7 percent in counties outside the study area. This suggests considerable room for potential revenues through income taxes in the area as a whole. In regards to sales tax, there are many counties which have not utilized the piggy-back option of 0.5 percent sales tax. Therefore, the percent sales tax revenue varies between 0 to 2.1 percent in the study area and 0 to 2.1 percent outside the study area. Here also there is a potential for generating more revenues. As will be obvious later in this report the potential for raising revenues from property taxes is negligible.

per year. The relative importance of these losses, ranges from the very small to over 14 percent of total county tax revenue in Crawford County. Finally, it should be noted that the relative impact of these tax losses is much smaller for the in-basin counties where all of the wastewater is produced than it is for the out-of-basin counties.[2]

Columns 5, 6, and 7 are based upon a particular land treatment plan calling for the use of 47,000 acres in-basin and 200,000 acres out-of-basin. The acreage figures for each county were derived by multiplying the percent of total available land (either in-basin or out-of-basin) by the total land requirement for the given area specified by the particular plan. Thus, the column 6 and 7 figures give a reasonable approximation of the total tax impact of an actual land treatment plan.[3]

The column 6 and 7 figures are, of course, much smaller than their column 3 and 4 counterparts. The impact, however, still appears quite significant in a number of cases. Two counties are shown losing over one quarter of a million dollars and three additional counties exhibit losses of over $100,000. The relative

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[2]This may prove to be a typical pattern since the areas producing the greatest quantities of wastewater are likely to be highly urbanized. Such areas will, in general, have less land available which is suitable for the land treatment of wastewater.

[3]The land treatment plan chosen represents a maximum land use. By selecting lands with higher application rates, it is possible that the land requirements could be reduced significantly. Never-the-less, concentration of the land sites would still give rise to most of the problems discussed in the text.

D. Revenue Capacity and Effort by Types of Taxes

1. Estimation Procedure

(a) Income Tax

(1) Actual Revenue

Total income tax out of personal income for each county (Col. 1, Table 1) was obtained by summing the net income tax collections (income tax collections after refund) of each municipality in that county. Net income tax collections out of personal income for each municipality were obtained by multiplying the net income tax collections (after refunds) out of all sources in each municipality of the county that institutes an income tax in Ohio by the proportion of net collections from personal income (wages, salaries, commissions) of each municipality.[1]

(2) Revenue Capacity and Effort

In order to estimate revenue capacity of income tax in each county we had to generate estimates of personal income for each county because of the unavailability of this data. Utilizing Census data for 1970, we calculated the total income from all sources in each county,[2] where Y_j, P_j and $\overline{Y}_j$ represent total

$$Y_j = P_j \overline{Y}_j$$

[1]Data Source: Statistics on Municipal Income Taxes in Ohio, Ohio Municipal League, Columbus, Ohio, 1971.

[2]Data on P_j and Y_j was obtained from Summary of Social Characteristics by Counties, General Social and Economic Characteristics of Ohio, Table 43 and Income and Poverty Status in 1969 for Counties in Ohio, Table 124, U.S. Bureau of Census, pc (1) - c 37, Washington, D.C., 1970.

income from all sources, population and average income of the jth county respectively. Summing Y_j's over all counties within a given SMSA (Standard Metropolitan Statistical Area) will result in total income from all sources for that particular SMSA. Assume that the proportion of a county's income from all sources within an SMSA to the total SMSA income from all sources is the same as the proportion of that county's personal income to the total personal income of the SMSA to which the county belongs. Then the personal income of the jth county can be obtained as follows:

$$b_j = \frac{Y_j}{\Sigma_j Y_j} \qquad (6)$$

and

$$Y_{pj} = b_j Y_{pj} \qquad (6.1)$$

where Y_{pj} and Y_{ps} are respectively personal income of the jth county within the SMSA and total personal income of the SMSA[3] to which the county belongs. After generating estimates of personal income for each county we estimated the revenue capacity of income tax (C_{IJ}) for each county by multiplying Y_{pj} by the average income tax rate. In symbols,

$$C_{IJ} = tY_{pj} \qquad (7)$$

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[3]Data on total personal income for SMSA and non-SMSA counties for selected years between 1929-1970 was obtained from <u>North-East Ohio Areawide Coordinating Agency</u> (NOACA) which generated this data from the tapes provided by U.S. Bureau of Census, Washington, D.C.

where t is the average income tax rate. Since most of the municipalities in different counties in the state of Ohio have an income tax rate of 1.0 percent, therefore t = 0.01. The capacity measure C_{IJ} suggests that the jth county would be able to raise revenues from income tax equal to C_{IJ} had it taxed its personal income at the average rate of t (see Col. 2, Table 2). Similar interpretation applies to capacity measures of other forms of taxes.

The revenue effort of income tax is the ratio of actual net income tax collections in the county to the revenue capacity. For example, Col. 3 Table 2 , Cuyahoga County is making 72 percent effort while Geauga is making 10 percent effort compared to their capacity to raise revenues from income tax. All the counties combined are making only 65 percent effort.

(b) Sales Tax

(1) Actual Revenue

To obtain revenue capacity and effort of sales tax the first step was to obtain the taxable retail sales for each county. We had data on sales tax collections by counties for the year 1970.[4] But this data includes not only state sales tax at the rate of 4.0 percent, but also the piggy-back sales tax at the rate of 0.5 percent allowed to the counties by law. But some counties have utilized this piggy-back option while some have not. In the case of counties which have piggy-back tax we

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[4]Sales tax collections by counties, Statement No. 4, 1971 Annual Report, Ohio Treasurer of State, Columbus, Ohio.

divided the county's sales tax collections by 0.045 and for those counties which do not have piggy-back sales tax, we divided their sales tax collections by 0.04 to obtain taxable retail sales. Therefore in counties which do not have piggy-back tax, the actual sales tax revenue will be zero and the revenue in counties which have 0.5 percent piggy-back tax, will be 0.005 times the taxable retail sales (Col. 4, Table 2).

(2) Revenue Capacity and Effort

Since 0.5 percent piggy-back tax is the maximum allowable tax rate, the revenue capacity of counties which utilize this option will be the same as actual revenue or taxes. On the aggregate we find that counties are making only 58 percent of the total possible effort of 100 percent.

(c) Property Taxes

(1) Actual Revenue

This is the sum of taxes levied in each county on real, public utility and tangible personal property.[5] Intangible property was disregarded because revenues from this source are committed by law to specific purposes e.g., libraries.

(2) Revenue Capacity and Effort

Capacity (Col. 8, Table 2) was obtained as follows:

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[5]Data was obtained from Assessed Valuation of Real Public Utility and Tangible Personal Property Taxes Levied by Local Governments in Ohio Due and Payable in Calendar Year 1971, Table 693 - 1969, Division of County Affairs, Department of Taxation, Columbus, Ohio.

Table 2. Revenue Capacity (1970-71)

Counties	Income Tax			Sales Tax			Property Tax[e]			Total Taxes Collected[h]		
	(1) Actual[a] ($000)	(2) Capa-city[b] ($000)	(3) Ef-fort[c] %	(4) Actual[a] ($000)	(5) Capa-city[d] ($000)	(6) Ef-fort[c] %	(7) Actual[a]	(8) Capa-city[f] ($000)	(9) Ef-fort[c] %	(10) Actual ($000)	(11) Capa-city ($000)	(12) Ef-fort %
Ashtabula	1,484	3,603	41%	0	424	0%	16,174	17,971	90%	17,658	21,998	80%
Cuyahoga*	57,214	79,151	72%	9,851	9,851	100%	430,442	334,996	128%	497,507	423,998	117%
Geauga*	253	2,421	10%	0	185	0%	12,505	10,790	115%	12,758	13,396	95%
Lake*	3,604	8,380	43%	1,031	1,031	100%	42,834	37,522	114%	47,467	46,933	101%
Lorain*	5,967	9,246	65%	0	1,203	0%	49,537	47,016	105%	55,504	57,465	97%
Mahoning	8,856	11,154	79%	0	1,379	0%	50,984	49,474	103%	59,840	62,007	97%
Medina*	473	3,166	15%	277	277	100%	13,191	12,738	103%	43,941	16,181	86%
Portage*	1,625	4,566	36%	322	322	100%	19,037	17,685	106%	20,984	22,573	93%
Summit*	17 814	22,585	79%	0	2,867	0%	109,537	101,619	107%	127,351	127,071	100%
Stark*	9,672	14,197	68%	0	1,575	0%	56,067	62,747	89%	65,739	78,519	84%
Trumbull	3,502	9,194	38%	0	808	0%	41,785	47,717	88%	45,287	57,719	78%
Wayne	958	3,083	31%	326	326	100%	13,836	14,856	55%	15,120	18,265	83%
Totals	111,422	171,132	65%	11,807	20,248	58%	855,929	755,131	113%	979,156	946,125	103%

a. Taxes collected in county
b. Capacity if all municipalities collected the state average income tax rate of 1%
c. Effort= Actual taxes/Capacity taxes.
d. Capacity if all counties instituted 1/2% piggy back tax

*Counties in the study area

e. Tax on Real + Public + Tangible Personal Property.
f. Capacity if all tax rates were uniform in all counties.
g. Totals for 12-county study area.
h. Taxes collected from Income Tax, Sales Tax and Property Tax

We converted the assessed valuation of real, public utility and tangible personal properties to their market values for each county by using the assessment ratios for each type of property.[6] The assessment ratios for real property varied from county to county[7] while the assessment ratio of 50 percent was used in the case of public utility and tangible personal properties.[8] Let us suppose that we obtain market value of real property (M_{Rj}), of public utility (M_{Pj}), and of tangible personal property (M_{Tj}) by using the above procedure. Then the average tax rate for real and public utility property combined is:

$$r_{RP} = \frac{\Sigma_j \; T_{RPj}}{\Sigma_j \; (M_{Rj} + M_{Pj})} \tag{8}$$

where T_{RPj} is the taxes levied on real and public utility property combined in jth county. We had to combine M_{Rj} and M_{Pj} because data on taxes levied is given for real and public utility property combined. The average tax rate on tangible personal property (r_T) is obtained by using equation (1). Therefore the revenue capacity of property taxes in each county (Col. 8,

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[6]Ibid.

[7]A Summary of Information in Regard to Equalization of Real Property Tax Values in Ohio for 1971 Tax Year, No. 757 A (1971), Division of County Affairs, Department of Taxation, Columbus, Ohio.

[8]This figure of 50 percent assessment ratio for public utility and tangible personal properties was provided by Keith Smith, Public Utility Department, Department of Taxation, Columbus, Ohio.

Table 2) is:

$$C_j + r_{Rp} (M_{Rj} + M_{Pj}) + r_T M_{Tj} \tag{9}$$

For example, revenue capacity of property taxes in Ashtabula is \$17,971,000 while in Cuyahoga it is \$334,996,000.

The effort (Col. 9, Table 2) is again the ratio of actual to capacity. It would be obvious from this column that a majority of the counties are making more than 100 percent effort. It is indicative of the excess burden placed on counties as regards to property taxes. There does not seem to be much hope of raising revenues from property taxes. On the aggregate all the counties in this study are making 113 percent effort; 13 percent more than warranted by their aggregate capacity.

2. Total Revenue Capacity and Effort

Summing the revenue capacity of income tax, sales tax and property taxes we obtain total revenue capacity (Col. 11, Table 2). Out of the total revenue capacity of \$946,125,000 of all counties combined, Cuyahoga's capacity is \$423,998,000 followed by Stark (\$78,519,000), Lorain (\$57,465,000) and others. Comparing this total capacity with actual revenues, all the counties combined are making 103 percent effort on the average. Note this average is boosted by 117 percent effort by Cuyahoga and 101 percent by Lake, even though other counties are making less than 100 percent effort (Col. 12, Table 2).

At this point we can draw one conclusion that the only feasible revenue sources are income tax and sales tax. We

can generate $59,710,000 extra revenue from income tax if all the municipalities in the respective counties institute 1.0 percent average tax rate, and $8,441,000 from sales tax if all counties levy 0.5 percent sales tax. There is another option open to the authorities. Instead of levying 0.5 percent piggy-back sales tax by those counties which do not have piggy-back tax, they raise income tax rate by 0.5 percent over and above the average rate of 1.0 percent. This will lead to an increase of approximately 36 million dollars over the above additional capacity of income tax. This amount is considerably greater than the additional sales tax capacity of approximately 8 million dollars and also represents a more equitable way to raise revenues.

E. Revenue Capacity and Effort by Utilizing Different Assumptions

The following assumptions were used for different taxes to compute the capacity and effort (Table 3).

1. An average income tax rate of 1.5 percent for all local governments. This assumption is fair and conservative as compared to other localities in the rest of the country where the maximum state income tax rate varies between 5.0 to 14.0 percent[9] while in Ohio it is only 3.5 percent.[10]
2. An average piggy-back sales tax rate of 1.0 percent. This assumption is also not out of line as a majority of local

[9] State and Local Government Finances, Significant Features 1967 to 1970, An Information Report, Advisory Commission on Intergovernmental Relations (ACIR), Washington, D.C., Table 40, November, 1969.

[10] This information is based upon the summary of the final act passed by Ohio Legislature on December 20, 1971.

Table 3 Revenue Capacity (1970-71)

	Income Tax			Sales Tax			Property Tax			Total Taxes Colledted[e]		
	(1) Actual ($000)	(2) Capa-city[a] ($000)	(3) Ef-fort[b] %	(4) Actual ($000)	(5) Capa-city[c] ($000)	(6) Ef-fort %	(7) Actual ($000)	(8) Capa-city[d] ($000)	(9) Ef-fort %	(10) Actual ($000)	(11) Capa-city ($000)	(12) Ef-fort %
Ashtabula	1,484	5,405	27%	0	848	0%	16,174	18,870	86%	17,658	25,123	70%
Cuyahoga*	57,214	118,727	48%	9,851	19,702	50%	430,442	351,683	122%	497,507	490,112	101%
Geauga*	253	3,632	7%	0	370	0%	12,505	11,457	109%	12,758	15,459	83%
Lake*	3,604	12,570	29%	1,031	2,062	50%	42,834	39,536	108%	47,469	54,168	88%
Lorain*	5,967	13,869	43%	0	2,406	0%	49,537	49,350	100%	55,504	65,625	85%
Mahoning	8,856	17,310	51%	0	2,758	0%	50,984	51,945	98%	59,840	72,013	83%
Medina*	473	4,749	10%	277	554	50%	13,191	13,464	98%	13,941	18,767	74%
Portage*	1,625	6,849	24%	322	644	50%	19,037	18,675	102%	20,984	26,168	80%
Summit*	17,814	33,878	53%	0	5,734	0%	109,537	107,020	102%	127,351	146,632	87%
Stark*	9,672	21,296	45%	0	3,150	0%	56,067	65,747	85%	65,739	90,193	73%
Trumbull	3,502	13,791	25%	0	1,616	0%	41,785	49,797	84%	45,287	65,204	69%
Wayne	958	4,625	21%	326	652	50%	13,836	15,636	88%	15,120	20,913	72%
Totals	111,422	256,701	43%	11,807	40,496	29%	855,929	793,180	107%	979,158	1,090,377	90%

a. Capacity if all municipalities collected 1/2% above the present 1% State Average Income Tax Rate.

b. Effort = Actual Taxes/Possible Capacity Taxes.

c. Capacity if all counties increased piggy back sales tax to 1%.

d. Capacity if all tax rates were uniform over all counties, as well as uniform assessment ratios of 35% for Real Property.

e. Taxes collected from Income Tax, Sales Tax, and Property Tax.

* Counties in the study area

governments around the county have this rate.[11]

3. A uniform assessment ratio of 35.0 percent in the case of real property. This ratio is frequently mentioned at the Department of Taxation at Columbus, Ohio, in an attempt to have uniform assessment practices. This attempt towards uniformity followed the recent decision of the Supreme Court of Ohio in State Ex Red Park Invest. Co. V Bd. of Tax Appeals on June 2, 1971.

Utilizing the above assumptions revenue capacities were calculated for all three types of taxes (Table 3.) We find an additional capacity of $145,279,000 in income tax, an additional capacity of $28,689,000 in sales tax. In the case of property tax capacity, in spite of uniformity in the assessment of real property, it is still lower than the actual property taxes. In other words all the counties combined are still making more than 100 percent effort which further confirms our belief that property taxes will not be potential revenue sources. The total effort is 107 percent (Col. 9, Table 3.) out of which Cuyahoga is making 122 percent effort, considerably larger than other counties. A more equitable solution can be found by redistributing the effort among counties and reducing the average effort from 107 to 100 percent and compensating this reduction of 7 percent by income tax and/or sales tax where the average effort is only 43 and 29 percent respectively. A 0.5 percent increase in income tax rate over and above 1.5 percent will more than compensate the revenue

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[11] Op. Cit., ACIR, Table 47.

decrease if we make the average effort in property taxes equal to 100 percent. Once again even this income tax rate of two percent for local government is not at all much in the light of a much lower State of Ohio income tax rate as compared to other states. In a similar manner some other possible schemes could be worked out given some serious thought to the tax situation in Ohio.

Without any of the above changes one can still raise an additional revenue of $111,219,000 because, on the average, counties are making only 90 percent of the effort (Cols. 10, 11, 12, Table 3). But there is still considerable room for raising income tax and/or sales tax rates as has already been suggested above. This room for more effort will further increase if we use some other comparable region (i.e. comparable in terms of wealth) or the nation as a standard in the computation of revenue capacities. The point is that Ohio has the wealth if it has the will to raise revenues for financing wastewater treatment program.

F. Conclusion

This report only considered existing sources of revenue and did not discuss the possibility of raising revenue from other forms of taxation such as corporate income tax which must be taken into account. Pollution charges on industries or other sources of pollution which pollute public waters is another way to finance the program and a very efficient one. But given the present forms of taxation, income tax and sales tax seem to be the most promising sources of revenue.

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Attachment F

THE IMPACT OF THE LAND TREATMENT OF WASTEWATER UPON LOCAL TAX REVENUES

The extensive use of land treatment techniques may require the land transfer of large amounts of land from the private to the public sector of the economy. If these lands are removed from the tax rolls when they are acquired by the public entity, serious tax losses may be inflicted upon some local governmental units. The extent of the potential tax losses is illustrated by the Table 1 figures.

Column 1 gives the total property tax revenue for all local governmental units within the listed counties. Columns 2, 3, and 4 are based upon the maximum amount of land in each county that was deemed suitable for land treatment of wastewater.[1] Since the maximum amount of land available in all counties combined far exceeds the amount required, these figures would not be simultaneously realized for all of the counties listed. It is possible however, that maximum usage will be approached in some individual cases.

The maximum potential impact is obviously quite large in a number of individual counties. Although it is unlikely that the maximum tax loss will be realized in very many cases, there are a number of counties that could conceivably lose close to $1 million

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[1]Tax revenue (Col. 3 and Col. 6) is based upon average county tax rates and the average value for agricultural land and buildings in each county. A preliminary investigation of selected land treatment sites indicated that their value was somewhat above the countywide averages used in Table 1. Thus, the figures presented in columns 3 and 6 are probably somewhat low. However, the error is certainly not large enough to affect any of the analysis based upon Table 1 data.

TABLE 1

COUNTY TAX REVENUE (1971) AND POTENTIAL TAX REVENUE LOSS ASSOCIATED WITH LAND TREATMENT OF WASTEWATER

County	1 Total Property Tax Revenue[1]	2 Maximum Land Treat-ment Acres[2]	3 Tax Revenue on 2[3]	4 Col. 3 ÷ Col. 1 (X100)	5 Estimated Land Treat ment Acres[4]	6 Tax Revenue on 5[3]	7 Col. 6 ÷ Col. 1 (X100)
IN BASIN							
Cuyahoga	$430,441,528	36,570	$ 865,612	.20	4,404	$ 104,240	.02
Geuaga	12,504,691	38,590	332,260	2.66	4,644	39,981	.32
Lake	42,834,006	24,220	279,014	.65	2,914	33,569	.08
Lorain	49,536,525	123,645	829,658	1.67	14,885	99,878	.20
Medina	13,190,500	91,680	669,264	5.07	11,036	80,560	.61
Portage	19,036,796	36,350	739,857	3.89	4,376	35,312	.19
Summit	109,537,492	39,385	808,180	.74	4,742	97,312	.09
TOTAL-in Basin	$677,081,538	390,440	4,523,845	.67	47,001	490,852	.07
OUT OF BASIN							
Ashland	$ 6,132,524	14,840	$ 88,446	1.44	4,800	$ 28,608	.47
Crawford	7,978,504	193,515	1,147,543	14.38	62,500	370,625	4.64
Erie	15,240,741	36,600	276,696	1.82	11,820	89,359	.59
Huron	8,110,283	183,720	957,181	11.80	59,340	309,161	3.81
Richland	23,602,021	18,525	89,105	3.8	5,980	28,764	.12
Sandusky	9,868,151	52,915	329,131	3.33	17,080	106,238	1.08
Seneca	9,063,783	89,965	438,129	4.83	29,060	141,522	1.56
Wyandot	2,988,928	29,165	130,367	4.36	9,420	42,107	1.41
TOTAL-out of Basin	$ 82,984,935	619,245	3,456,598	4.17	200,000	1,116,384	1.35
GRAND TOTAL	$760,066,473	1,009,685	$7,980,443	1.05	247,001	$1,607,236	.21

Source notes Table 1.

1. "Assessed Valuation of Real, Public Utility and Tangible Personal Property: Taxes Levied by Local Governments in Ohio Due and Payable in the Calendar Year 1971" Mimeo from State Department of Taxation, Columbus, Ohio, January 10, 1972.

2. Wright McLaughlin Engineers Appendix: Land Treatment Technical Data (U.S. Army Corps of Engineers, Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study), Table II-1, "Classifcation of Soil Associations Selected as Potential Land Treatment Areas."

3. Derived from average value per acre of agricultural land and buildings contained in a letter from Mr. Dale Teeters, Supervisor, General Section, Division of County Affairs, Board of Tax Appeals. No information was supplied for Cuyahoga and Medina counties. The Summit County value was used for Cuyahoga and for Medina, a weighted average of the figures for Geauga, Lake, Lorain and Portage counties was used.

4. Derived from Wright McLaughlin Engineers Formulation Technical Appendix: Development of Array of Alternative Regional Plans for Wastewater Management, "Plan 4" (U.S. Army Corps of Engineers, Cleveland-Akron Three Rivers Watershed Wastewater Management Survey Scope Study), November, 1972.

per year. The relative importance of these losses, ranges from the very small to over 14 percent of total county tax revenue in Crawford County. Finally, it should be noted that the relative impact of these tax losses is much smaller for the in-basin counties where all of the wastewater is produced than it is for the out-of-basin counties.[2]

Columns 5, 6, and 7 are based upon a particular land treatment plan calling for the use of 47,000 acres in-basin and 200,000 acres out-of-basin. The acreage figures for each county were derived by multiplying the percent of total available land (either in-basin or out-of-basin) by the total land requirement for the given area specified by the particular plan. Thus, the column 6 and 7 figures give a reasonable approximation of the total tax impact of an actual land treatment plan.[3]

The column 6 and 7 figures are, of course, much smaller than their column 3 and 4 counterparts. The impact, however, still appears quite significant in a number of cases. Two counties are shown losing over one quarter of a million dollars and three additional counties exhibit losses of over $100,000. The relative

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[2] This may prove to be a typical pattern since the areas producing the greatest quantities of wastewater are likely to be highly urbanized. Such areas will, in general, have less land available which is suitable for the land treatment of wastewater.

[3] The land treatment plan chosen represents a maximum land use. By selecting lands with higher application rates, it is possible that the land requirements could be reduced significantly. Never-the-less, concentration of the land sites would still give rise to most of the problems discussed in the text.

impact is rather large in Crawford and Huron counties and also important in Sandusky, Seneca and Wyandot. The difference between the in-basin and out-of-basin counties is very marked. Over two-thirds of the total tax loss falls upon the out-of-basin counties. The relative impact is also far greater for the out-of-basin counties.

It would be virtually impossible to acquire 200,000 acres of land from among the out-of-basin counties in such a way that none of these counties would lose a significant amount of tax revenue. Furthermore, efficiency in the operation of a land treatment system would undoubtedly dictate much more concentration of land sites than is depicted in column 5.[4] Thus, some counties are quite likely to bear a much larger burden than is shown for them in column 6. This could be particularly important for counties with relatively low total tax revenues and large quantities of land suitable for land treatment, e.g., Crawford and Huron. Finally, county-wide figures may not be the most relevant for present purposes. Many, if not most important public functions within the counties are handled by smaller political subdivisions, e.g., schools, police and fire protection. An analysis of the smaller political units would undoubtedly show a much greater relative importance of the tax impact in a number of individual cases.[5]

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[4]For instance, the proposed in-basin land treatment areas are much more concentrated in Medina, Portage and Geauga and less concentrated in Lorain in particular than the column 5 figures would indicate.

[5]The data necessary for such an analysis is not readily available. The county analysis is capable of pointing out the basic difficulties involved.

In summary, the data presented in Table 1 seems to support the following conclusions:

1. The aggregate size of the potential tax loss is not completely insignificant, reaching as it does an amount in excess of $1-1/2 million per year.
2. The loss imposed upon particular political units is likely to be very important in some instances.
3. The distribution of the potential tax loss is very uneven and it is not necessarily related to the distribution of benefits to be derived from the project.

Two questions remain to be answered. First, should the tax revenues on the land be considered in the costing of alternative systems? It appears that an affirmative answer is called for. The costs to be included for any system should relate to the value of the output which could be produced by the appropriated resources in their alternative private sector uses. For most resources other than the land and buildings to be acquired for land treatment sites these costs are closely approximated by market prices. In the case of land and buildings, the market prices will reflect the discounted value of the output of these assets after property taxes have been deducted.[6] To obtain the full measure of the value produced by

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[6] The output of all assets, including land and buildings, used in the private sector is subject to profits taxes. This complication should be taken into account when the appropriate discount rate is selected. For a discussion of the problems involved see William J. Baumol, "On the Social Rate of Discount," The American Economic Review Vol. LVIII No. 4, Sept., 1968, and Comments by Alan Nichols, Estelle James, Carl Landauer, David Ramsey and Dan Usher, and a Reply by Baumol in ibid Vol. LIX No.5, Dec., 1969. Property taxes imposed upon land and buildings are peculiar to these assets and they must be considered separately.

these assets in the private sector the discounted value of the tax payments should be added to the market prices.[7]

The addition of taxes on land and building to the costs of land treatment systems will not significantly increase the relative costs of these systems. The annual tax payments for the land system summarized in columns 5, 6, and 7 of Table 1 is $1,607,236. The total estimated annual costs for this system are $382,093,000. The addition of the tax figures is clearly incapable of significantly affecting the choice between land and water based technologies.[8]

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[7]Some of the acreage being considered for land treatment is not currently being used for any production purpose. This land has a short-run opportunity cost of zero but in most instances the market price obviously reflects the expectation of a future use for the land. If land treatment could be undertaken only for the period during which the land would otherwise lie idle, then the proper value of the land (taxes included) to be used in costing the project would be zero. Actually, the acreage must be committed to land treatment for approximately 50 years thus effectively eliminating expected future uses of the land. In this case, the market value including discounted tax revenues seems to be the appropriate figure to use in costing the project.

There is an additional complication associated with the use of unproductive acreage for land treatment. The land treatment itself may lead to an increase in economic activity in the area which in turn will generate higher sales and income tax revenues. These higher sales and income tax revenues might offset the loss in property tax revenues particularly where the value of the unproductive acreage is low. The same complication may be relevant, but to a lesser degree, where productive acreage is appropriated for land treatment.

[8]The annual cost figure actually represents annual comparative value. For a discussion of the derivation of annual comparative value see Wright-McLaughlin Engineer, (U.S. Army Corps of Engineers, Cleveland-Akron Metropolitan and Three Rivers Watershed Area, Wastewater Management Survey Scope Study), Land Treatment Phase II Section VI. The same principle should of course be applied to any land and buildings acquired for use in the water based systems. This will further mitigate the effect of adding the taxes to the costs of the land based systems.

The same point may be illustrated by comparing the present value of the annual tax payments listed in column 6 with the capital costs of the land treatment system used in their derivation. The present value of a perpetual annuity of $1,607,235 discounted at 7 percent is $22,960,514. The capital cost of the land treatment system is $4,030,973,000. Once again, the impact of the tax cost is minimal.[9]

The second question is: will the tax losses have to be replaced and if so, how can this best be accomplished? On equity grounds it is quite clear that the tax losses should be replaced. There is simply no justification for inflicting a $1 million annual tax loss on the out-of-basin counties to cope with a wastewater problem generated exclusively in-basin. Inequitable distributional effects would also be associated with uncompensated tax losses within the basin. The larger counties, i.e., Cuyahoga and Summit, would not bear a tax loss burden proportionate to their share of the total wastewater produced. These equity considerations may, however, be much less important than questions of political practicality. Land treatment is continually confronted by serious public opposition. The inflicting of tax losses upon political subdivisions containing land treatment sites could easily render impossible the achievement of public approval of land treatment systems.

There are basically only two ways in which the tax losses

[9]The present value of the tax payments would, of course be larger if a lower discount rate were used. For instance, the $1,607,236 annuity is worth $32,144,720 when discounted at 5 percent. This is still rather small when compared to the total capital costs. In addition, capital costs represent only two-thirds of total system costs.

could be replaced: (1) through a lump sum payment, or (2) by rendering the lands controlled by the public entity taxable on the same basis as privately owned lands.[10] In either case it would be necessary to determine the future value of the land to be used for wastewater treatment. This would be extremely difficult in the case of a lump sum payment since the value of land and also prevailing tax rates would have to be estimated far into the future. If the public entity were taxed, the land value could be determined simply by applying an average rate of increase on similar land to the sale price of the public parcels. Neither method is perfect, but the taxing of the public lands appears capable of more accurately replacing the tax loss. It is possible, however, that the local governmental units involved will prefer a lump sum payment. If this is the case then the wishes of the local governments should certainly be granted unless an unrealistic rate of land value appreciation is used in arriving at the proposed lump sum payment.

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[10] The necessity for replacing the tax losses would obviously not arise if the land treatment sites were left in private hands.

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Attachment G

ECONOMIC CONSIDERATIONS RELATING TO CHEMICAL AND ENERGY REQUIREMENTS OF ADVANCED WASTEWATER TREATMENT

Large amounts of a number of chemicals will be required to treat the wastewater from the Three Rivers Watershed region. The chemical requirements and costs for the three basic technologies involved are summarized in Table 2. The quantities were based upon projected year 2020 wasteloads. Current prices supplied by engineering consultants, Havens and Emerson, were used to arrive at the cost estimates.

The Table 2 figures illustrate two important points. First there is a major difference in the magnitude of the chemical requirements between land and water based technologies. Land treatment requires comparatively small amounts of chemicals whereas chemical costs account for over 20 per cent of total operations and maintenance (O and M) costs for the water based technologies. Second, the requirements for individual chemicals differ significantly between the physical-chemical and advanced biological processes. Physical-chemical treatment requires large quantities of chlorine, calcium oxide and polymers. The advanced biological process makes greater use of alum and methanol.

These observations relating to chemical requirements would have little more than descriptive value if unlimited quantities of each of the chemicals could be provided at constant cost (or at a cost rising over time no faster than the general price level). In this instance, the current cost figures would incorporate most of the relevant considerations and further concern would be unwarranted.[1]

[1]Chemical production may also generate adverse environmental effects which have not as yet been reflected in chemical prices.

Table 1

Annual Wastewater Treatment Chemical Requirements and Costs for Alternative Technologies in the Three-Rivers Watershed

	1 Land Treatment	2 Advanced Biological Treatment	3 Physical Chemical Treatment
Lime Tons/yr.[a]	7423		
Price/ton[b]	20.00		
Total Cost[c]	148,450.00		
Ferric Chloride			
Tons/yr.	3711		
Price/ton	100.00		
Total Cost	371,110.00		
Chlorine			
Tons/yr.	10,451	4789	124,681
Price/ton	100.00	100.00	100.00
Total Cost	1,045,090.00	478,860.00	12,468,070.00
Alum			
Tons/yr		17,695	
Price/ton		520.00	
Total Cost		9,201,608.00	
Calcium Hydroxide			
Tons/yr.		68,182	72,511
Price/ton		15.20	15.20
Total Cost		1,036,366.00	1,102,166.00
Calcium Oxide			
Tons/yr.			152,224
Price/ton			20.00
Total Cost			3,044,472.00
Methanol			
Tons/yr.		60,931	
Price/ton		100.00	
Total Cost		6,093,050.00	
Polymer			
Tons/yr.		441	1,897
Price/ton		2,500.00	2,500.00
Total Cost		1,101,750.00	4,742,750.00
Total Cost All Chemicals	1,564,650.00	17,911,634.00	21,357,458.00
Total O & M Costs[d]	69,958,000.00	84,661,000.00	94,158,000.00
% Chemical to O & M Costs	2.3	21.2	22.7

(a) All quantities derived from Tables D-2 and D-3 Havens & Emerson Phase II Report.
(b) All prices supplied by Havens and Emerson.
(c) Total costs were calculated prior to price and quantity rounding.
(d) Obtained from Sheets 4-A, 10-A, and 11-A of Blue Book Formulation Technical Appendix Development of Array of Alternative Regional Plans for Wastewater Management from Wright-McLaughlin Engineers.

We cannot, however, be at all certain that constant cost production will in fact be possible.

There is little reliable published information available upon which to base chemical price projections for extended periods into the future. The probability of rapidly rising chemical prices should be increased by rapidly rising levels of demand. The Table 2 figures undoubtedly represent only a small portion of the increased demand for chemicals generated by our heightened national awareness of water quality problems. If a significant portion of the nation attempts to meet the newly imposed federal wastewater treatment standards with treatment methods similar to those summarized in Table 1, the chemical demand figures will increase accordingly. To illustrate the potential national impact, Table 2 was constructed by assuming that 30 percent of the nation adopted treatment methods similar to those being considered for the Cleveland-Akron area. (Since approximately two percent of the nation's population lives in the Cleveland-Akron area, the Table 1 quantities were multiplied by 15 to yield the Table 2 quantities.

The national requirements presented in Table 2 represent a substantial increase in current production levels for ferric chloride, chlorine, calcium hydroxide, calcium oxide and methanol.[2]

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[2]The use of 1970 production figures is somewhat misleading. The national requirements given would not be reached for a number of years and production of all of these chemicals will increase even in the absence of a new higher level of demand for wastewater treatment purposes. The following growth rates in production have been projected for the decade of the 1970's: Ferric Chloride - 6% (through 1976) - Chemical Profile, Ferric Chloride, OPD Chemical Marketing Reporter, Feb. 28, 1972; Chlorine - 7% (through 1974) - Chemical Profile, Chlorine, OPD Chemical Marketing Reporter, July 13, 1970; Methanol - 10% (through 1975) - Chemical Profile, Methanol, OPD Chemical Marketing Reporter, Feb. 27, 1971. While these growth rates are rapid, it does appear that the increased demands for wastewater treatment purposes will represent a significant addition to the projected production levels.

Table 2

Annual Wastewater Treatment Requirements
for Selected [a] Chemical for 30 per cent of the U.S. Population
and 1970 National Production

	1 Land Treatment	2 Advanced Biological Treatment	3 Physical Chemical Treatment
Lime:			
30% National Requirement (NR)[a)]	11,337		
1970 Production[b)]	19,747,000		
%NR to 1970 Production	.06		
Ferric Chloride			
NR	55,667		
1970 Production c)	69,244		
% NR to 1970 Production	80.39		
Chlorine			
NR	156,763	71,829	1,870,210
1970 Production d)	9,600,000	9,600,000	9,600,000
% NR to 1970 Production	1.63	.75	19.48
Calcuim Hydroxide			
NR		1,022,730	1,087,664
1970 Production b)		3,126,000	3,126,000
% NR to 1970 Production		32.72	34.79
Calcium Oxide'			
NR			2,283,354
1970 Production b)			15,248,000
% NR to 1970 Production			14.97
Methanol			
NR		913,958	
1970 Production e)		2,465,841	
% NR to 1970 Production		37.06	

a) 1970 production data were not available for Alum and Polymers.

b) All NR derived from Tables D-2 and D-3 Havens and Emerson Phase II Reports

c) Minerals Yearbook, 1970, U.S. Bureau of Mines

d) Current Industrial Reports, Series M28A, Bureau of the Census

e) "Outlook Seventies," Chemistry and Engineering News, December 15, 1969

f) Synthetic Organic Chemicals, U.S. Production and Sales, U.S. Tarriff Commission

We do not have the information available to determine if these rapid increases in demand will generate large price increases, but it does not seem prudent to ignore completely this possibility. In addition, it is quite possible that prices will be forced up much more rapidly for some chemicals than for others. Both a general rise in chemical prices and a marked change in the relationship among individual chemical prices could have an important bearing upon the selection of optimal treatment systems throughout the country.

If the increased chemical demand for wastewater treatment does result in significantly higher chemical prices, then the use of current prices in comparing alternative technologies will bias the choice in favor of the water based systems. The extent of the bias will, of course, depend upon the magnitude of the rise in chemical prices. This problem is a specific illustration of a more general problem which always arises when planning necessitates the projection of prices far into the future. The use of current prices implicitly makes two assumptions: (1) that the relationship between prices entering into the costs of the systems being considered and prices in general will remain constant, and (2) that the relationships among the different prices determining alternative system costs remain constant. If the first assumption fails to hold then the estimate of the overall cost for the project being considered will be incorrect. For instance, in the present case, if treatment costs rise much more rapidly than prices in general then the real cost of wastewater treatment will be greater than the estimate based upon current prices.

When the second assumption fails to hold, a bias may be intro-

duced into the choice among alternative technologies.[3]

There is a further complication which might prove very important. Assume that the extent of the increase in chemical prices is, to a significant degree, dependent upon the chemical demand for wastewater treatment. The choice between the advanced biological and the physical-chemical processes would then be an important determinant of the pattern of future changes in chemical prices. Concentration upon the advanced biological process would result in relatively rapid rises in the prices of alum and methanol whereas a movement toward the physical-chemical process would generate more rapid increases in the prices of chlorine, calcium oxide, and perhaps polymers. In other words, the choice of a particular treatment method would generate price changes which, over a period of time might render this method more expensive than other alternatives.

Under these circumstances, current prices simply cannot be used to choose among alternatives. Furthermore, it would appear highly questionable in such a situation to allow all localities to choose their own treatment technology. No locality will use enough chemicals to have a significant impact upon chemical prices. But if all localities operating independently choose the same process based upon current prices then the difficulties outlined above could materialize. These difficulties would not materialize, or

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[3]It is always possible that a detailed investigation of all cost components for both land and water based systems would uncover probable changing price relationships capable of generating an offsetting bias. Therefore, we cannot conclude on the basis of an examination of chemical price changes alone that the costing procedures are actually biased in favor of the water based systems.

would not be very serious, if the wastewater treatment decisions of localities were spread over a long period of time. In this case, localities postponing their decision to a later date would be able to observe the changing chemical prices generated by the earlier decisions of other localities before they made their choice. This would cause a movement toward an optimal mix of technologies on a national level. But if recent water quality legislation is enforced, then all localities will be required to commit themselves to treatment technologies over a relatively short period of time. To make optimal long run choices, localities would need detailed information about both the technologies adopted by other communities and the impact of these choices upon future costs. They undoubtedly will not have such information and thus it is not unreasonable to conclude that the local choice option will lead to a nonoptimal mix of technologies from a national point of view.

Past price behavior is definitely not an adequate guide to future price changes in this situation. We may, however, gain some idea of the potential impact of price increases by examining selected price changes that have occurred in past years. The 1971 methanol price was approximately 22 percent below the highest price recorded after 1952.[4] The 1970 chlorine price was 36 percent above the lowest price prevailing after 1952.[5] If the prices of

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[4]"Methanol Fortunes Take Turn for Better," Chemistry and Engineering News, Oct. 9, 1972.

[5]Chemical Profile, Chlorine, OPD Chemical Marketing Reporter, July 13, 1970.

these chemicals were again to change by these relative amounts, the impact upon the relative costs of the two water based treatment technologies would be significant. Annual chemical costs for the physical-chemical process would rise by about $4-1/2 million thus raising O and M costs from $94.2 million to $98.6 million. A cost reduction of $1.3 million would occur in the advanced biological process thereby reducing O and M costs from $84.7 million to $83.3 million. The resulting increase in differential costs of almost $6 million per year could be quite important in the selection of the least cost alternative.[6] The possibility of even larger cost changes emanating from changes in chemical prices is clearly present.

With the exception of past price data and the actual chemical requirements for the various technologies, everything included in the preceeding account is pure speculation. We do not know which of the chemicals involved can be produced under conditions of constant cost over the relevant output ranges. We thus do not know what the increased demand for these chemicals for wastewater treatment purposes is likely to do to their prices. We are not knowledgeable in relation to the technological possibilities for substituting other chemicals for those currently being used or projected for use in wastewater treatment. We cannot, therefore, be certain that the chemical requirements for wastewater treatment, as large as they may be, actually present a problem when it comes to the selection of appropriate treatment methods. We do feel, however,

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[6]The relative impact of this change would be diluted somewhat when capital costs were added to the picture. The impact would still be significant since capital costs only account for about 1/3 of total costs for the water based technologies.

that our speculation has pointed out significant potential difficulties associated with the chemical requirements and by so doing has illustrated that further study of this matter should be undertaken before a large part of the nation commits itself to particular treatment techniques.

Accordingly we recommend the undertaking of a detailed study of the production and marketing conditions for the chemicals involved in wastewater treatment covering:

1. Projections of chemical prices with particular emphasis upon the potential impact of demand increases emanating from higher levels of wastewater treatment. Both production and distribution costs should be carefully considered.[7]
2. The possibilities for mitigating the impact of higher chemical prices through substitution within the basic wastewater treatment technologies being considered
3. The need for national coordination in the selection of wastewater treatment technologies based upon the results of 1 and 2.

Certain additional aspects of this problem might also be considered with little extra effort. It would be useful to determine if the heavy use of chemicals for wastewater treatment would significantly affect other sectors of the economy. An effort should also be made to clarify the adverse environmental effects associated with large increases in the demand for chemicals and the costs involved in eliminating these adverse effects.

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[7]There may be special distribution problems associated with the movement of chemicals to treatment plants located close to densely populated areas.

2. Energy and Other Resources

The cost of energy and chemical resources required for the treatment of the wasteload of the Three Rivers Basin represents, in a very real sense, only the tip of an iceberg. The potential escalation of costs and the environmental sacrifices that must be made, lend a major impact to the local consumption of resources in wastewater management.

For example, the computation of power required for the achievement of Level 1 (State Goal) in Plan 1, includes power consumed in primary treatment, in aeration and by the use of microstrainers. The total consumption estimated in the treatment of 795 mgd is 2040 megawatts per day. At the current cost of $0.0121 per KWH, the daily cost is $24,684.00. The most modern coal fired plants produce a kilowatt of power from .76 pounds of coal, 760 pounds per megawatt, or about 775 tons daily for the above load. The annual coal requirement will be 283,000 tons which will produce, using current air pollution control technology, 14,000 tons of sulfur oxides, 2,700 tons of nitrogen oxides, 270 tons of particulates, 75 tons of carbon monoxide, 27 tons of other hydrocarbons, and 34,000 tons of solid waste ash for disposal. The annual requirement of 744,600 megawatts of power will also produce over 825,000 megawatts of waste heat from the most efficient technology available.

The use of such massive amounts of power will require new power plant construction within the service area. In 1971, the East Central area of the nation, of which Ohio is a part, had a power reserve of less than 14%, with a 20% reserve considered necessary to insure against power failure. New plants, and presumably older ones, will be required to abide by prohibitions against thermal pollution. Once-

through-cooling has been used in many current plants where a major source of water supply exists. such as Lake Erie. Limitation of temperature increases to receiving waters under new standards would require such fantastic increases in flow as to make this method completely infeasible. Current technical alternatives are wet cooling towers and the use of impoundments, either with or without spray treatment. Cooling towers evaporate about twice as much water as most other cooling methods and usually require the construction of huge concrete structures, frequently dwarfing the stations they serve. Cooling ponds, on the other hand, require many acres of land adjacent to the power plant. The Federal Power Commission has assumed a minimum surface area of 5 acres per megawatt would be required for fossil fuel plants. Efficiency of a cooling pond may be increased by introducing a spray into the system, allowing lesser land acreage.

The EPA has estimated the cost of air pollution abatement to power generation would average a 7% to 9% increase. Local power company officials have given estimates as high as 60%. The cost of thermal pollution abatement may run, in addition, from \$4-\$6 per kilowatt capacity for cooling ponds and from \$8 to \$13 per kilowatt capacity for cooling towers. The most appealing approach to cooling problems is to make beneficial use of waste heat for district heating or cooling, winter agriculture, warm water aquaculture, or a variety of other uses, including, as suggested in several plans, the partial treatment of sewage effluent in a mutually beneficial configuration.

In addition to the control of air and thermal pollution, other social and environmental problems facing the use of coal are health and safety in mining, the reclamation of mined land surfaces, water pollution from acid mine drainage, and the disposal of solid waste.

While methods to desulfurize coal, and to control all stack emissions to current standards, are currently under study, they are not yet economically viable. The development of environmentally suitable means to assure the continued high level of surface mine production is essential; otherwise, vast reserves of coal will remain inaccessible, and the remainder only available at much higher costs. The significance of this to the State of Ohio should be obvious, and hopefully, will be reflected in the seriousness of consideration of the strip mine reclamation techniques suggested.

There is a direct relationship between the cost of environmental control, the cost of electric power, and the current and developing energy crisis. The average cost of coal burned for electrical generation has increased 50% since 1969 and part of this has been attributed to a switch to low sulfur coals which are more costly because of lower reserves and longer shipping distances. The costs of residual oils and natural gas, also used for electrical generation, have shown increases of 30% and 20% respectively in the last several years. The reserves of natural gas and petroleum have diminished while the demand for energy has continued to grow.

The U.S. supply of natural gas, which is one of the most convenient and pollution-free forms of energy, has been projected for complete exhaustion in 12-14 years. Power companies are being constrained to burn low sulfur oil to reduce the sulfur dioxide pollution. The resultant increased import of hydrocarbons seems likely to increase much more. These imports are already responsible for much of the deficit in our balance of payments. It has been indicated that continuation of present trends will surely lead to deeper deficits, more devaluation, and loss of confidence in the U.S. dollar.

Recent events have served to strengthen this prediction. As the percentage of imports relative to our total use grows, the nation becomes increasingly vulnerable to petroleum blackmail.

Although coal has been, and will remain for the rest of this century, the greatest source of electrical energy, the cost of power will respond uniformly to the cost of pollution control technology and the cost of pollution-free fuels. A federal study proposes that the government institute an energy use-tax which would not only increase the cost of energy, but hopefully, also conserve its use. Methods of energy conservation have been suggested by many studies, and major companies such as U.S. Steel, DuPont, and Eastman Kodak have full-time programs to implement such conservation. The National Science Foundation in its study of the energy problem, has indicated sizeable opportunities for conservation in the better management of both fuels and effluents in housing, stating "merely the economic reduction of waste represents a fertile area" (for investigation of energy savings).

The concern for conservation of energy in the selection of a wastewater management plan must also be reflected in a similar review of the chemical resource requirements of the individual plans. While the chemicals used in the treatment process tend to be common, rather than exotic, the quantities range from 60 to nearly 1,000 tons a day depending on the plan. The previous section has detailed the economic considerations relating to chemical requirements. There are a variety of concerns about price increases, scarcity, reliability of supply, and relation to other resources. The incessant failure of treatment plants due to lack of chemical application for cost or other reasons is well known. The problem may be magnified where quantities are

greater. The manufacturing requirements of these chemicals in themselves may constitute environmental hazards, as, for instance, the manufacture of chlorine by the chlor-alkali process that has contributed such a burden of mercury to our waters. Methanol production faces similar pollutional problems, with the discharge of hydrocarbons. While environmental control is possible, there is a cost factor attached.

The consideration of resource scarcity should not neglect the potential of resources present in wastewaters. While nitrogen may be freely available from the air, phosphorus has a visible limit. Of the many elements required for life, phosphorus appears to be the most important from the standpoint of its low abundance in the environment. Phosphate mining has increased 843% during the period from 1940 to 1969. Increased use of fertilizers and the widespread use of detergents accounted for the bulk of the increase. It has been estimated that the supply of phosphate rock will last for less than 60 years at our current rate of mining. Since phosphorus compounds move for the most part only within the liquid phase of the hydrologic cycle, it is for practical purposes non-cyclic. Our current culture is living in an utterly spendthrift way on the resource accumulations of the past, a resource of phosphate rock that only future millenia can reproduce.

One must question either the intelligence or the sanity of the practice that disperses a limited resource from a readily available wastewater concentration to very low concentrations in the ocean floor or otherwise dispersed in water and biota, especially when other alternatives are possible. (Typical phosphorus content in

secondary treatment plant effluent is 8,000 ppb compared to the oceans' 40-100 ppb.)* The end result of the current and projected man-dominated phosphorus flow pattern will be to render most of the world supply of phosphorus to nonavailable storage where it would require very high energy expenditures to recover it. The effect on the food supply of future generations can be imagined.

While the example of phosphorus is dramatically close to our food supply concerns, other resource uses must be similarly assessed. The United States is a "have not" nation in terms of our declining mineral resources. Yet our rate of utilization increases annually (almost 20 tons per capita in 1971 , and must be reflected in increased imports of crude and processed minerals. The $10,000,000,000 worth imported in 1971 adds in considerable measure to the balance of payment problems discussed under energy costs.

The interrelationship of scarcity to wastewater management costs has yet to be assessed, but the possibility of major constraints in economic factors and in resources cannot be dismissed.

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Attachment H

POLITICAL ACCEPTANCE OF INNOVATION IN WASTEWATER MANAGEMENT AND TECHNOLOGY

The introduction of a regional wastewater system which utilizes new methods of treatment involves rather significant technical and governmental innovation. Lacking adequate data on attitudes of local officials and others, the best we can do is to make some general observations which may at times degenerate to speculations.

It is important to keep in mind the "problem" involved in establishing a regional system. There are really a couple of different kinds of problems which should be kept distinct. The first might be called the legalistic; involved here are questions relating to such matters as constitutional limitations on debt, financing, etc., or statutory law on creation of administrative districts and authorities. These matters are of obvious importance and need to be researched carefully. But they are not real constraints on innovation; any lawyer or administrator worth his salt should be able to come up with ways of circumventing legal kinds of prohibitions. Unfortunately, most of the institutional research seems to have been directed to the legalistic problem. To the best of my knowledge, relatively little hard research has been done on the political problem of innovation and, in my opinion, this is the most crucial as the project approaches the implementation stage.

As a general rule of thumb one can assume that the more innovative a project the more likely it is to encounter political difficulties. However self-evident this observation, it is important to keep in mind when thinking about changes in existing policy. In some basic ways, the idea of a regional water treatment system runs counter to the traditional approach to public problems in the state. As pointed out in the previous discussion of state-local relations, the traditional political approach in Ohio has been for the state to free local govern-

ments to do what they want to do. That is, local discretion has been defined as fundamentally good. Experience with the problems of regional planning would seem to support this. Whether planning and sewage treatment at the regional level can be legitimately compared is debatable. The former does involve long range decisions about the general development of communities; the latter is much more specific, involves a hardware function and probably is not, at this point in time, a truly significant issue for most people. But the simple point is that imposition of a regional activity does run counter to governmental traditions in the state.

It is dangerous to think that any major innovation can simply be imposed on a region of the state. Even if one is willing to concede that the land treatment method is the most economical, efficient and sound from a technical point of view, he cannot assume that local officials are going to define it in the same terms. This is not to say that the officials are behaving irrationally, they are simply viewing the problem from a different perspective. Those seeking to innovate must be sensitive to the fact that they may be asking the officials to pay what are to the officials significant political costs. At the very least these potential costs could involve:

1. Loss of tax revenue through a loss of tax base.
2. Loss or dilution of control over a governmental function.
3. Loss of local political support from elements--e.g., mass media, homeowners, etc.--who view the innovation as a foolish kind of exercise.

Rather clearly every effort should be made to counteract the "costs" argument. This will require some careful cultivation of three critical audiences--local officials, the mass media, and the

general public. Since they will be the final decision makers the most important group is probably that of the public officials. This is obvious. It is difficult even to speculate in any meaningful way about possible public reactions to any new system. To the extent that large scale disruption of local activity is involved--relocation of families, acquisition of farm land, construction, etc.--one would expect opposition from those directly affected. But for the more general public the system may be of no great consequence. On this point, the local mass media takes on a critical role, that of local political agenda setting. In effect, the local press defines for the people what are salient political issues. The media does not necessarily tell people what to think on a topic but does tell them what topics to think about.

This may be a round about way of citing the obvious. Nevertheless, it cannot be assumed that the project will be implemented in any "revolutionary" way. Cultivation of local officials and the media is important. This is particularly true when one is considering the adoption of a new treatment system which will probably involve an administrative structure that, to date, has not been widely used in Ohio.

1. Institutional Aspects

Specific features of the plans for wastewater management in the Three Rivers Watershed are sufficiently distinct from current treatment as to warrant general discussion prior to plan-by-plan evaluation. Such features are the institutional implications of efficiently treating stormwater runoff, and the plans' regional focus of wastewater treatment for the physical scope of the Three Rivers Watershed.

Stormwater Runoff

(a) Practicality of Public Control of New Development

A thoroughly effective land use guidance system to achieve maximum control of stormwater runoff would require that all new development in the watershed be (1) clustered in planned unit developments, (2) adjacent to existing development and wastewater management facilities, and (3) built at moderate to high densities with a large proportion of garden apartments and other multi-family dwelling units. Such a system would require more stringent controls of private property than would be feasible at the present time. However, an only slightly less effective system, probably at 80% of the total system above, could be accomplished by the existing subdivision review process. This would require (1) revision of subdivision regulations to provide more explicit attention to stormwater runoff, (2) careful and competent review at the county level by regional or county planning commissions, (3) installation of stormwater runoff collection facilities by the subdivider at his cost, and (4) some contirbution by each individual subdivider to the capital costs of a treatment system. This is quite feasible politically. Subdivision regulations are familiar to all counties; county and

regional planning commissions exist in all counties, and placing the financial burden on the developer is quite acceptable. The only thing necessary to make this system a reality would be the drafting of model regulations, informing county commissioners and large cities of the advantages of such regulation, and strengthening the hand of the regional planning commissions in the regulation process, which they have been carrying on as a routine matter for some years. The major difference between this politically feasible guidance system and the relatively infeasible, stringent system first described is that it would result in smaller treatment facilities. Thus, some economies of scale in treatment facilities might not be possible to achieve.

(b) Political Feasibility of Plant Regionalization

If the public is made aware of the need for the control and treatment of stormwater runoff, it is likely to be a politically acceptable objective of public policy. The current lack of attention to the problem is more a matter of lack of information than of political conflict. There is no reason for large plants to be politically less feasible than small ones; if the county sanitary engineers are responsible for this function (and there is no reason why they would not be), much "regionalization" of facilities would take place as a matter of course. For drainage areas spanning county boundaries, the feasibility of two-county agreements would be quite high. Thus, there is no institutional reason why large plants should not be considered.

On the other hand, relatively small plants may result, not because of the difficulty of governmental structures, but because of the inability to control the location and timing of new development.

As indicated in (a) above, the land development process is likely to result in relatively smaller plants for technical reasons, not political ones.

(c) Overflow in Relation to Design Storm

It would be important from an institutional point of view to avoid spills, and other accidental or intentional discharge of untreated wastes, to water bodies in the region. Such discharges are the types of environmental issues that make good newspaper copy; they are dramatic, and they can be photographed, thus making them eminently newsworthy subjects. For reasons of institutional credibility, planning should minimize the chance of accidental or intentional discharge of untreated wastewater, with the question of cost being the obvious tradeoff. We should be willing, however, to pay some substantial cost to avoid the negative political consequences of such discharges.

2. <u>Institutional Change</u>

There is some tendency to restrict the meaning of "institutional change" to those dramatic and revolutionary events that result in entirely new governmental structures, such as metropolitan government, area-wide multi-purpose special district, or state assumption of what was heretofore a local responsibility. It is important not to fall into this trap. "Institutional change" can occur by an evolutionary process through such simple devices as subdivision regulations, the employment of competent professional staff, the upgrading of the planning capabilities of a planning commission, or the adoption of new county health department regulations. The cumulative effect of such small changes may produce large changes in system output. Additionally, it may be noted that institutional

change may generate from increased coordination between state and regional/county/local agencies, effecting a workable wastewater management plan for the watershed while avoiding complex problems of new governmental structures.

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Attachment I

DISTRIBUTIVE EQUITY IMPACT OF A REGIONAL WASTEWATER TREATMENT SYSTEM

The implementation of any proposal entailing significant costs carries with it the potential for major redistributive effects. The sheer magnitude of the wastewater treatment project under study for the Three Rivers Watershed area necessitates a careful investigation of equity considerations. Differential effects may occur with respect to each of the following:

1. Geographic Areas. There are a number of possible causes in this case. There will definitely be marked geographic differences in the improvement in water quality. In very general terms the Chagrin and upper Cuyahoga areas will experience the smallest improvements in water quality simply because they are currently in the best condition. This obviously reduces the relative share of the project benefits to residents of these areas. The differential involved is, however, very difficult to quantify. Residents of other parts of the watershed undoubtedly use the water facilities in the Chagrin and upper Cuyahoga areas and some residents of these areas make use of the water in other parts of the watershed.

The geographic impact of the indirect effects associated with the project will also be distributed unevenly. Prominent examples are the risks emanating from possible system failure and the external effects accompanying land use changes. Finally, there will be some differential impact upon municipal and industrial water supplies and upon local tax bases.

2. Specific Individuals. Some families will incur costs, both monetary and psychic, due to relocation. It is also possible that the major land value changes will fall not upon entire geographic (political) areas but largely upon specific individuals within these areas.

3. Income Class. The costs and benefits of the project may not be distributed in the same manner among income classes. Thus the situation of some groups will be improved, in a relative sense, at the expense of others.

Compensating arrangements appear to be feasible in a number of cases under the first two headings. Changes in local water supplies and tax bases can be measured and compensation could be effected by levying differential user fees or through the use of tax rebates. Individual relocation costs can be approximated and must be paid. Payments covering only monetary costs are inherently conservative since, by definition, they ignore psychic costs. From an efficiency point of view the treatment of these compensating payments is not a matter of choice. They must be considered in cost calculations or it will be impossible to determine if the game is worth the candle. From the point of view of equity, the payments actually must be made if we are to avoid significant and haphazard redistributions of income. It is, therefore, strongly recommended that these payments actually be made and that they be adequate in size.

In theory, the risk of system failure must also be considered as one of the compensable costs of the project. Quantifying these costs and identifying the individuals or localities who will bear them is extremely difficult if not impossible. Since it may be

impossible to compensate for the bearing of these risks it is tempting to argue that the systems should be made as risk free as is technically feasible. But this really does not come to grips with the problem. Various levels of risk will have to be evaluated, if only implicitly, and the resulting cost of the risk weighed against the cost of reducing it. This is the only way in which an optimal system can be designed. In practice this issue is quite likely to be decided on political grounds with the affected parties supplying their own estimates of the cost of the risks involved.

Land value changes are also extremely difficult to measure. Indirect, and often offsetting changes are potentially important and very elusive. Once again, from an efficiency point of view these land value changes must be considered if the project is to be costed correctly. In this case, equity raises a host of confusing issues that seem to defy generalization. Each individual case may have to be decided upon its own merits although legal precedent in the U.S. seems to lean against the payment of compensation for land value reductions.

The payment of significant compensation for property value reductions could give rise to a further problem. Since the windfall gains associated with property value increases might not be measurable and undoubtedly could not be recovered, an efficient project, i.e., one for which aggregate benefits exceed aggregate costs, might not be undertaken because of the resulting overstatement of the net costs associated with land value changes. The opposite is, of course,

also possible if the increases in land value are readily apparent and the decreases are not. This may very well be the case where water quality improvements are the most visible and widespread results of the project.

It appears virtually impossible to avoid some redistributive changes due to effects upon property values. Compensating payments for property value losses appear feasible, if they are judged desirable, but there seems to be no practical way of appropriating and redistributing the windfalls accruing from higher property values.

The differential impacts of water quality changes give rise solely to equity problems. Should the residents of areas possessing higher quality water resources and having no significant waste disposal problems be required to participate on the same basis as residents of areas with low quality water and major disposal problems? If all individuals are free to locate anywhere in the region, then it seems that a negative answer is clearly in order. Those who chose to locate in the high water quality areas did so because they placed a high value upon the availability of the water resources and the associated environmental amenities. This choice often entails giving up other advantages present in the low water quality areas. It thus seems inherently inequitable to require the residents of the high water quality areas to pay a full share for upgrading the water resources in the low water quality area. Low water quality is, in effect, being voluntarily consumed and paid for by the existence of offsetting environmental characteristics, e.g., the cultural amenities and higher wage levels generally found in large urban areas.

Residents of high water quality areas should be required to bear part of the financial burden. There will, hopefully, be region-wide benefits and also some improvement even in the high water quality areas. Once again, the difficulty lies in arriving at the appropriate amounts.

The validity of this argument is strongly dependent upon the assumption of free location choice in the housing market. If individuals were, in some manner, prohibited from living in the high water quality areas then we could no longer be sure that their "choice" to locate in a low water quality area was optimal. That is to say, given their occupational and educational constraints, they might have preferred residence in the high water quality area had they been allowed to obtain it. In such a case, the residents of the low water quality area would not currently be receiving adequate offsetting benefits to compensate them for their "loss" of high quality water. Requiring the residents of the high water quality areas to bear their full share of the proposed project would therefore be equivalent to the partial elimination of the artificial restrictions prohibiting the residents of the low water quality areas from moving to the high water quality areas.

The most prevalent restrictions upon free choice in housing location are based upon race and economic status. If racial or economic discrimination in housing does exist in an area, this fact can be demonstrated but the process involved is generally expensive and time consuming. Many of our ghetto building policies are designed to improve the inner city environment in partial payment

for the artificial restrictions that continue to hold persons in these areas. Inner city problems are very important in the Three Rivers area but, with the exception of possible redistribution effects among income classes, their relationship to the wastewater management alternatives appears quite peripheral. The anticipated improvements in water quality will have a relatively small impact upon inner city residents. In addition, the housing restrictions keeping the poor in the central cities have undoubtedly not been concentrated in high water quality areas.

In quantitative terms, the most important redistributive effects relate to the differential treatment of income classes. Approximately 80 percent of the watershed area residents live in Cuyahoga and Summit counties. The effect of the redistributive factors discussed above upon the residents of these counties appears to be minimal. But the wide range of income classes present in these counties and throughout the watershed makes the selection of appropriate financing methods a matter of paramount importance.

To determine what constitutes appropriate financing it is first necessary to specify the redistributive goals of the project. There is clearly no thought of using the project to affect a major redistribution of real income; it is simply an inappropriate tool for such a purpose. Ideally, then, we might wish to select a method of financing which would leave the distribution of real income unchanged. This has at least two major advantages: (1) it allows decisions relating to redistribution to be made independently and on their own merits, and (2) it automatically provides a mechanism for determining if total project benefits exceed total project costs. Financial burden would be allocated on the basis of benefits received and thus

a worthwhile project should receive the endorsement of the public. If it is not possible to match perfectly the costs and benefits among the various segments of the public then we may wish to select a financing scheme which is not, on balance, regressive, i.e., a scheme which will not reduce the income of the poor.

The major difficulty associated with the implementation of either of these alternatives relates to the measurement and assignment of project benefits. Since it is so difficult to quantify the benefits, it may be more productive to assume that these benefits are equally distributed or to assume simply that the benefit distribution cannot be determined and to concentrate upon the distribution of project costs. Thus, the cost incidence associated with a number of different financial alternatives will be calculated and compared. This alone will not allow us to choose "the" best among the various alternatives but it will facilitate a discussion of their relative merits. Before this is attempted, however, one very crude estimate will be made of the distribution of benefits among income groups.

Some of the benefits emanating from the project are virtually impossible to quantify and to allocate among income groups, e.g., increases in property values. Other benefits appear to be widely, although not perfectly evenly, distributed over the region's population, e.g., reductions in the acquisition and processing costs for municipal water supplies. But the major justification for the project must stem from the benefits accruing to direct users of the higher quality water for recreational purposes and from the general amenity value associated with having clean water throughout the region.

The data in Table 1 represents an attempt to allocate project benefits among income classes by using the number of water-based recreation participation days for the various income groups. This procedure is admittedly much easier to criticize than to defend. Many of the region's residents may place a positive value, and perhaps a high one upon cleaner water in the region even though they make no recreational use of this water themselves. It is, however, possible that participation in water-based recreation activities is positively correlated with the general amenity value that an individual places upon having clean water throughout the region. The use of a participation day as a unit of account may also prove misleading. The value placed upon a participation day may vary among activities and among income groups. The principal justification for using this procedure is that we don't have a better hole to go to.

The Table 1 figures show a markedly progressive distribution of benefits. This is true on a per person, per family and an aggregate basis. Columns 4 and 6 show that the bottom 11-1/2% of the income distribution receives less than 1-1/2% of aggregate benefits; that the bottom 37% receives 17% of total benefits, and that the upper 1/3 of the family income distribution receives approximately 1/2 of the total benefits. This may, however, be a very deceptive way of viewing the problem. In order to make the distribution of benefits comparable to the distribution of costs, we must either place the cost distribution on an aggregate basis or the benefit distribution on a per dollar of income basis.

Table 1

Benefits of Improved Wastewater Management in the Three Rivers Watershed Area Derived from Water-Based Participation Rates

Family Income*	1 Partici-pation Days Per Person+	2 No. of Persons Per Family	3 (2) (1) Total Partici-pation Days Per Family*	4 Number of Families	5 (4) (3) Total Partici-pation Days	6 % Distri-bution of Benefits
1858	2.78	2.01	5.59	105,846	591,679	1.32
1858- 3715	7.07	2.70	19.09	81,477	1,555,396	3.47
3715- 5572	9.93	3.13	31.08	73,111	2,272,290	5.07
5572- 7430	11.18	3.48	38.91	81,946	3,188,519	7.12
7430- 9908	14.55	3.71	53.63	136,126	7,300,437	16.31
9908-12385	16.25	3.72	60.45	133,992	8,099,816	18.09
12385-18578	17.39	3.79	65.91	166,839	10,996,358	24.56
18578 plus	18.87	4.05	76.42	140,928	10,769,718	24.05

*Includes unrelated individuals. The original income classes were 1500, 1500-2999, 3000-4499, 4500-5999, 6000-7999, 8000-9999, 10,000-14,999 and 15,000 +. These classes were used to present recreation data for 1960-61. They were placed upon a 1969 base to render them comparable to the income distribution data by applying the increase in the consumer price index from 1960 to 1969--U.S. Department of Labor, Bureau of Labor Statistics, Handbook of Labor Statistics 1970, Washington, D.C., Table 120.

+Includes Swimming, Fishing, Boating, and Water Skiing. Winter months (Dec.-Feb.) have been excluded for all categories except fishing.

Sources: Col. 1 - Outdoor Recreation Resources Review Commission, National Recreation Survey, Washington, 1962 (ORRRC Study Report 19) Tables 1.02 (.05, .08, .16, .18); 2.02 (.05, .08, .16, .18); 3.02 (.08); 4.02 (.05, .08, .16, .18).

Col. 2 - Bureau of the Census, Current Population Reports: Consumer Income, Series P-60, No. 37, January 17, 1962, Table 5.

Col. 4 - U.S. Bureau of the Census, Census of Population: 1970 General Social and Economic Characteristics, Final Report PC (1)-C37 Ohio Table 89. Figures include both the Cleveland and Akron SMSA's (Cuyahoga, Geauga, Lake, Medina, Summit and Portage Counties). Income classes were combined by linear interpolation.

Table 2 contains information designed to facilitate a direct comparison between the cost and benefit distributions generated by the project. The tax rates shown in column 2 are based upon an illustrative project cost of one billion dollars. These rates have been adjusted to produce an aggregate cost distribution identical to the benefit distribution shown in column 6 of Table 1. In other words, if a one billion dollar project generating the benefit distribution shown in column 6 of Table 1 were financed with the tax rates shown in column 2 of Table 2, the relative distribution of real income would remain unchanged. In general, the rate structure exhibited in column 2 is highly regressive, more regressive in fact than the fiscal structures utilized by most states and localities. Columns 4 and 5 demonstrate the effect of financing the project with a proportional rate structure. This would result in a significant redistribution of real income from the higher income classes to the lower income groups. Assuming that aggregate benefits equal aggregate costs, proportional financing would redistribute about 10% of the total project value.

These conclusions seem to contradict generalizations based upon casual empiricism. It is often argued that environmental improvement is a rich man's game since the well-to-do benefit most from these improvements and financing is generally accomplished with a regressive tax structure. The empirical observations may be correct, but they do not necessarily support the conclusion that environmental improvement redistributes real income from the poor to the rich. The argument overlooks the fact that even a highly regressive tax structure may place much higher aggregate burdens upon the rich.

Table 2

Cost Incidence Alternatives for Improved Wastewater Management in the Three Rivers Watershed Area Based Upon the Table 1 Benefit Structure

Income Class	1 Assumed Average Income	2* Equalizing Tax Rates (Average)	3* Cost per Family for Col.2 Rates	4* Cost Dist. for Proportional Rate of 10.715%	5** Net Benefits for Proportional Rate of 10.715%
< 1,858	$ 1,500	8.31%	$ 124	1.70%	- .38%
1,858- 3,715	2,786	15.28	426	2.43	1.04
3,715- 5,572	4,643	14.93	693	3.64	1.43
5,572- 7,430	6,501	13.37	869	5.71	1.41
7,430- 9,908	8,669	13.82	1,198	12.64	3.67
9,908-12,385	11,146	12.11	1,350	16.00	2.09
12,385-18,578	15,481	9.51	1,472	27.68	- 3.12
18,578 +	20,000	8.53	1,706	30.20	- 6.15

*Figures are based upon an assumed project cost of $1 billion (chosen solely for illustrative purposes), the number of families given in Col. 4 of Table 1 and the assumed average income for the income classes shown in Table 2.

**Based upon Col. 6 Table 1 and Col. 4 Table 2. A minus sign indicates that costs exceeded benefits for the income group in question, e.g., for the highest income group, costs exceeded benefits by 6.15% of total project costs. Total project benefits were assumed equal in value to total project costs. The sum of Col. 5 does not total zero due to rounding errors.

When this occurs, as it does in the Three Rivers area, a project with a highly progressive benefit structure financed by a highly regressive tax structure may have little or no effect upon real income distribution.

But even a reasonable explanation of the Table 1 and 2 results is unlikely to render them acceptable in many quarters. There is a strong temptation to adjust the estimation procedures to alter the conclusions. The cost, or tax estimates are relatively straight forward. The only assumption made relates to the selection of the average income for each income class. In this case, the figure for the lowest income class may be a bit high and the figure for the highest class is definitely much too low. A correction of these biases would lead to greater regressivity in the equalizing tax rates and to a greater redistribution toward the poor when a proportional rate is applied.

The benefit measures could be adjusted in a number of ways. Basically some form of conversion might be attempted to put the benefit measures in value terms rather than in terms of physical units. This might be accomplished by determining what people would be willing to pay for their recreation participation or by using travel costs as a proxy for value. This would undoubtedly raise the benefit levels for the higher income groups relative to those of the lower income groups.

In the present case, it is impossible to implement this approach since we do not have the data necessary to make the conversion. But it is possible to gain at least a qualitative impression of the impact that specified refinements might have upon the Table 1 results.

The most obvious change would result directly from the conversion to value terms. We can be relatively certain that a very large income effect will cause the recreation days of the rich to carry a much higher value than those of the poor. Before such a change could be incorporated, however, it would be necessary to make a further adjustment. The relevant values must relate to the change in the quality of the recreation experience rather than to the total value of the participation days shown in column 5 of Table 1. Both the income pattern by type of activity and the geographical location of changes in water quality should tend to mitigate the increased progressiveness of the benefit structure brought about by the conversion to value terms.

Of the three major forms of participation,* boating would be the least affected by water quality changes. Boating accounts for almost 20 percent of participation and exhibits a benefit pattern that is significantly more progressive than the average overall activities. Fishing which accounts for approximately 30 percent of participation may benefit appreciably from improvements in water quality. The distribution of benefits for fishing shows marked progression only for the lowest income class. Participation is relatively constant between incomes of $3,715 and $18,578. The activity most affected by the changes should be swimming. This accounts for over 45 percent of total participation and exhibits a progressivity of benefits that is slightly below average. It is quite probable, hwoever, that much of the swimming participation

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*Water skiing participation accounts for less than 3 percent of the total.

of the upper income classes takes place in private facilities that would not be strongly affected by the project. On balance then it seems reasonable to conclude that the conversion to value coupled with the considerations examined above would result in a more progressive benefit structure but that the difference would not be very large.

The conclusion receives further support when the location of changes in water quality and potential changes in participation rates are considered. Currently, the poorest quality water is located close to the relatively heavy concentrations of poor persons in central city Cleveland and Akron. In general, the poor are unable to travel far enough to make use of the higher quality water in other parts of the region. Cleaner water located at a reasonable distance may thus give rise to significant benefits for the poor community. These benefits would accrue largely in the form of increased participation rather than through improvements in the quality of existing participation. This seems particularly likely in the case of swimming where the major effect of low water quality may be to eliminate swimming completely. Changes of this nature cannot be captured by the Table 1 figures since they refer exclusively to existing participation patterns.

Finally, the conversion to value terms implicitly assumes that the distribution of non-recreational benefits is more closely approximated by the value distribution than by the distribution of physical units. This assumption has a reasonable ring, but it is very difficult to substantiate. This assumption may be crucial since the non-recreational benefits are likely to be quite important.

This is illustrated by the participation figures given in Table 1. Preliminary cost estimates indicate that project justification based solely upon upgrading the quality of roughly 45 million participation days in water-based recreation would require that the value of each of these recreation days be increased by at least $3.* Even allowing for a generous increase in participation due to the project, it is obvious that general esthetic benefits must play a major role.

With better data an attempt could be made to improve upon the benefit distribution presented in Table 1. But in the end one would have to be very skeptical of any results generated with the aid of the numerous "soft" assumptions necessary to deal with the problems discussed above. It would be difficult to overcome the suspicion that the benefit distribution had been manipulated to support a tax structure which was intuitively regarded as equitable. Virtually any tax structure could in fact be supported by selectively including some considerations and excluding others. To simply acknowledge that the tax structure or cost distribution is to be chosen solely on intuitive equity grounds may be preferable to the painful intellectual thrashing about necessary to provide "objective" support for the suggested financing scheme.

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*Based upon the lowest cost for achieving the lowest standard plus a conservative estimate of the costs imposed upon the area's industries.

Attachment J

TECHNOLOGICAL UNCERTAINTIES: AERATED LAGOONS

The use of waste stabilization lagoons for the treatment of domestic sewage, is neither new nor unusual. The Federal Water Quality Administration in their publication "The Economics of Clean Water" states that there were over 3500 in existence in 1970, or about 27% of all waste treatment facilities owned by municipalities. The major value of the lagoon has been the opportunity afforded small towns to have a water based sewage disposal system that has provided reasonable treatment (under previous standards) at a low capital cost. Much of the experience and research has related to small systems, some serving less than 200 people. Some ponds may be less than half an acre in size. There are no indicated upper limits to the size of the community that may be served by stabilization ponds except as limited by land costs. The size of any one pond has finite limits, but with split flows and parallel installations, very large cities could use them.

1. Lagoon Types

Conventional lagoons are generally considered to be an aerobic facility, meaning that the biological processes are carried out in the presence of freely available dissolved oxygen. However, organic solids settling to the bottom undergo anaerobic decomposition. The pond (so-called oxidation) may actually be a facultative system. Normally, lagoons are dependent on nature for two basic oxygenation processes: Surface reaeration and photosynthesis by algae. Aerated lagoons were a predictable outgrowth of the oxidation pond concept. When organic loading rates exceeded a natural limit, machinery was used to artificially induce oxygen at higher rates and therefore improve effluent quality. Since aerated lagoons could produce a

satisfactory BOD removal, with increased loadings over a shorter detention period, less land could be used. This has stimulated the development of this type of treatment throughout the 1960's.

The term aerated lagoon is a general description applying to a variety of processes which create different degrees of artifical mixing and oxidation. The design of aerated lagoons centers on the provision of a favorable environment for the microorganisms. One can identify three basic types: (1) the completely mixed aerated lagoon, (2) the facultative aerated lagoon, and (3) the aerated oxidation pond.

The completely mixed aerated lagoon is an activated sludge aeration basin without any sludge return and where all solids are maintained in suspension. All organic stabilization is dependent on suspended bacteria. Oxygen is machine derived and algae are not generally apparent. The effluent from the basin will be identical to the liquid in the aeration basin and will contain synthesized bacterial solids, the remaining soluble BOD and any inert solids carried in the effluent. There is a minimum detention time in the lagoon, below which a failure in treatment will result. This time is dependent on the ambient temperature and will increase as the temperature goes down.

The facultative aerated lagoon has a degree of mixing which will permit heavier solids to settle in the lagoon while biologically treating suspended and soluble organics in the liquid portion. The oxygen transfer is primarily by machine although algae may be present and participate in a small degree. The solids on the bottom are decomposed by benthal oxidation. The surface of the deposit is oxidized aerobically and the level below which oxygen does not

penetrate is oxidized anaerobically. Liquified anaerobic end products diffuse from the sludge deposit and are oxidized aerobically in the liquid phase. Oxygen demand in the fluid portion is lower than in a completely mixed lagoon since BOD is also removed by sedimentation. Less power is required for mixing and aeration and better use is made of the detention time.

In an aerated oxidation pond, considerable dependence on algae is noted, even with mixing and aeration equipment added. One of the most prevalent aeration devices used is gas diffusion through a plastic hose distribution systems. Extensive solids deposition does take place. With both bacterial and algal removal mechanisms operating, design of an overall removal rate becomes a problem, and most designs are based on BOD removal in the liquid phase only. The cost of construction of aerated lagoons is almost directly proportional to detention requirements; therefore, capability predictions are essential. The other factor that affects the sizing of aerated lagoons is the volume required for sludge accumulation. The 1970 Symposium for Waste Treatment Lagoons reported that there was a need for adequate data on the acceptable design and operation and the expected results from aerated lagoons, with the indication that most lagoon design was on a "cut and try" basis.

2. Problems

There are a variety of problems associated with lagoons but few that allow a direct comparison with a system combining land treatment. Oxidation ponds may produce hydrogen sulfide odors, highly colored, algae laden effluents, algae blooms, excessive organic matter in effluents, mosquito and insect breeding, etc.

Both effluent and aesthetic quality failures will occur. The major problem is one of inconsistency. The environment is virtually beyond the control of the designer and only such factors as depth, aeration input and loading can be controlled to a degree. In relation to discharge to receiving waters, an Illinois study[1] reported that acceptable effluents could not be achieved for BOD and Suspended Solids by any type of aerated lagoon. Other authors report acceptable effluents when ponds are combined in series, or when effluents are released after months of treatment.

Other problems are found in the type of aeration used. The plastic oxygen diffusion systems have a tendency to plug with sedimentation, with the resulting increase in pressure causing compressor failure. Surface type aerators tend to ice up in winter; also, the high level of turbulence produced results in a rapid dissipation of heat, leading to more icing. Recent studies indicate the formation of a barrier effect at the interface at lower temperatures, inhibiting oxygen transfer. Temperature is a major factor to be considered in Northern Ohio. Studies indicate that while BOD removal efficiency may be fairly high at 60 degrees F, below 55 degrees the process may deteriorate. Under these circumstances

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[1]Barsom, G.M. and Ryckman, D.W. "Evaluation of Lagoon Performance in Light of 1965 Water Quality Act." Second International Symposium for Waste Treatment Lagoons, Kansas City, Mo. 63 (1970).

a longer detention time is required. The statement is made[2] that present theory does not predict aerated lagoon reaction rates accurately, particularly for lower temperatures. From the literature, one must doubt that they can be depended upon to produce high quality effluents during the winter months. If the detention time is based on winter conditions, the detention time becomes exceedingly long when high BOD removal is specified. The total power input that is required for mixing may therefore become excessive.

3. Australian Experience[3]

The often cited Australian experience is not readily comparable with our conditions. The waste from Melbourne averages 50 mgd with only 15% industrial (Pop. 2,400,000). They have a multi-stage series of lagoons starting with anaerobic cells, and use an area of 3200 acres of lagoons to protect the effluent from the effects of temporary overloads or unequal distribution within the pond system. Their winter operating temperatures are no less than 50 degrees F.

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[2]Bartsch, E.H. and Randall, C.W. Aerated Lagoons - A Report on the State of the Art, Journal, Water Pollution Control Federation 43, 699 (1971).

[3]Parker, C.D. Experiences with Aerated Lagoons in Australia. Second Symposium for Waste Treatment Lagoons, Kansas City, Mo., 334 (1970).

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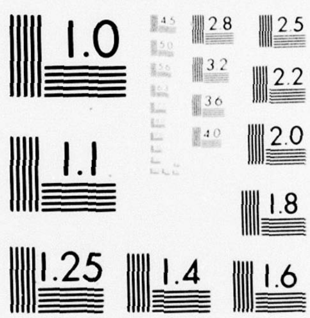

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

Attachment K

AN OUT-OF-BASIN ALTERNATIVE

1. Introduction

The Corps of Engineers' contract limits the present study to those land treatment areas within the Lake Erie drainage. This limitation thus removes from consideration a treatment plan which may prove to be the most feasible of all. The upper Tuscarawas drainage contains large areas of land suitable for spray irrigation or other types of land treatment. Chili, Wooster, Canfield and other suitable soils, plus stripmined areas are relatively plentiful in this region. This area includes most of Stark County and parts of Columbiana, Carroll, Harrison, Tuscarawas, Holmes, and Wayne Counties. This area hereafter will be referred to as the Southern-Out-of-Basin Area (S.O.B.).

"Generalized Soil Maps" were available only for Stark and Columbiana Counties. Within the S.O.B. area these are the counties located nearest the basin. The Stark County S.O.B. area contains 19,456 acres of Loudonville-Wooster soils and 113,152 acres of Chili-Wheeling-Shoal soils; Columbiana County contains 10,368 acres of Wooster-Canfield-Chili soils. Of the total 142,976 acres of suitable soils in these two counties, approximately 25,984 acres are urbanized. Thus, 116,992 acres are potentially available for land treatment of wastewater. At a 2020 projected average daily flow of 654 mgd[1] and an

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[1]654 mgd is the combined average daily flow (including stormwater) from the North Olmsted, Rocky River, Lakewood, Westerly, Southerly, Easterly, Euclid and Willoughby Eastlake Plants.

application rate of 60 inches per year, 146,514 acres of suitable soils would be required.

The only readily available source of information on soil types for the remainder of the S.O.B. area is the "Know Ohio's Soil Regions" map.[2] This map identifies only seven broad soil associations. The general soil type found in the part of Columbiana County used in plan 12 also characterizes most of Carroll, Harrison, Tuscarawas, and Holmes counties. It therefore appears likely that large amounts of suitable soils are located in the S.O.B. areas outside of Stark and Columbiana Counties.

In 1961 30,600 acres of stripmined land were available in the S.O.B. area. Assuming a growth rate of 2,300 acres per year,[3] in 1980 there will be 76,600 acres of stripmined land available for land disposal. At a 2020 average daily flow of 654 mgd and an application rate of 200 inches per year,[4] only 43,945 acres would be needed. Thus, it would be possible to treat the entire projected flow on stripmined land.

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[2] Published by Department of Natural Resources, Division of Land and Soil, Columbus, Ohio (1962 Revision).

[3] This is the estimated annual increase in stripmined lands within the S.O.B. area.

[4] This application rate has not been the subject of detailed investigation; it is used at this time simply for illustrative purposes. But, as the discussion below indicates, we do feel that application rates of this general magnitude may be feasible. It should also be noted that even a very substantial reduction in this 200 inch application rate would not eliminate the possibility of treating the entire projected 2020 flow on stripmined land. The 654 mgd would precisely "exhaust" the 76,600 acres of projected stripmined land at an application rate of 115 inches per year.

The flow could, however, be distributed on some combination of stripmined and other lands. Effluent distribution costs might be minimized by selecting the combination of stripmined and non-stripmined land closest to the basin.[5] For example, if 1/2 of the flow was applied to stripmines and the remaining 1/2 to other lands, only 21,972 acres of stripmined land and 73,257 acres of non-stripmined land would be needed to dispose of a flow of 654 mgd. There is enough non-stripmined land available to meet this requirement in Stark and Columbiana counties alone.

Returning the treated water to the Lake Erie drainage, to fulfill requirements of the 1909 Boundary Waters Treaty[6] with Canada, is made easier by the fact that the Cuyahoga River at Akron is lower in elevation than the Tuscarawas many miles to the south. One possible scheme for treatment would entail carrying all of the secondary treated effluent proposed for delivery to the western lands under plan 12 in a tunnel from the Cleveland Southerly Plant to a suitable reservoir to the south. This reservoir could be located in the area east of Hartville where the Cuyahoga, Mahoning and Tuscarawas basins meets, although other possibilities do exist. Tunnels from the lake front plants west of Cleveland would be smaller than

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[5]The minimization of effluent distribution costs is not an acceptable goal in itself. Other costs must also be considered, eg., land purchase and thus the combination of land sites which minimizes distribution costs may not be the combination which minimizes total costs. Distribution costs are, however, important enough to warrant separate consideration at a preliminary stage in the investigation of alternatives.

[6]This treaty is formally called the "Treaty with Great Britain Relating to Boundary Waters and Questions Arising Between the United States and Canada".

those in plan 12, since they would have to carry less water. The tunnel from the Southerly Plant southward would also be smaller due to its shorter length and consequently small friction loss. This would decrease the cost of taking the water from the basin. In plan 12 an 18 foot tunnel 343,000 feet long is used. At $750 per foot, the total cost of the tunnel would be $257,250,000. A tunnel from Cleveland Southerly to Hartville would only be 16 foot in diameter and 195,360 feet in length. At $650 per foot the total cost of this tunnel would be $126,984,000, less than one-half the cost of a tunnel to the west in plan 12. The reservoir site mentioned above would have little natural drainage, and would be in a good position for further transmission of effluent either to the strip mines south of Canton or to the agricultural lands to the west and south.

The return point would be from the Dover Reservoir. This would permit the return of water from any point in the drainages of the upper Tuscarawas River, Sandy Creek, Chippewa Creek, Conotton Creek, or, with a short diversion, Sugar Creek, an area totaling about 1,693 square miles. A number of alternative methods exist for returning this flow. For example:

(a) A gravity flow tunnel from the Tuscarawas River (Dover Reservoir) near Bolivar to the Cuyahoga River at its confluence with the Little Cuyahoga. Such a gravity flow tunnel would be 16 ft. in diameter and 186,240 ft. in length. At $650 per ft. the cost of this return tunnel would be $121,056,000, and the total tunnel cost of the

S.O.B. area $248,040,000. The return tunnel costs offset most of the original savings of going to the S.O.B. area, but the plan 12 proposal still entails 9,210,000 more in tunnel costs alone.

(b) A pipeline with pumping stations from Dover Reservoir to the drainage divide just west of the Little Cuyahoga. A hydroelectric plant at the confluence could reclaim most, if not all, of the power required for pumping. The pipeline could follow the Ohio Canal route for much of the distance.

(c) A pipeline to the headwaters of Breakneck Creek (Congress Lake outlet) with natural drainage down to the Cuyahoga just below Lake Rockwell. This would maximize low flow enhancement in the river, but might require channelization of the creek.

(d) A similar pipeline which then continued further, discharging directly to the Cuyahoga.

Further inquiries should also be made to determine if permission could be obtained to forego the return of the water to the Great Lakes drainage. Our preliminary investigation indicates that present downstream water users (primarily power companies) would demand large payments to compensate them for the proposed flow diversion.

2. Possible advantages of this concept over others considered include the following:

a. Costs

(1) The total cost of the tunnel, including both effluent and return tunnels, would be somewhat less than that of any of the land plans involving the use of lands in Western Ohio.

Lower total friction losses would thus permit the use of smaller tunnels. Further savings might be realized by employing pipelines for the return flow instead of a tunnel.

(2) Stripmined lands could be used for treatment of large amounts of effluent, with application rates perhaps as high as 200 inches or more per year. This would reduce costs in a number of ways. Less land and therefore less irrigation equipment and site preparation would be required due to the higher application rates. The cost of the land itself would be quite low, and there would be little or no relocation involved. The application of effluent to stripmined lands would result in some leaching of minerals, including acid-producing sulfides and heavy metals, but the total amount would undoubtedly be less than that found in the surface runoff today.

b. Versatility

Because the effluent could be used on either stripmined lands or agricultural land, an option would exist for varying the amount going to each as the effluent supply, need and public acceptance changed.

c. Phasing

The time delay caused by the construction of tunnels and the difficulty of gaining public acceptance for spray irrigation of effluent could be overcome with a phasing process similar to the following: The first step would be to activate the sludge pipeline and to apply sludge to stripmined land while the effluent tunnel was under construction.

By the time the tunnel is completed, the stripmined lands could be restored sufficiently to accept high application rates of effluent. Within the drainage area described above, there are presently more than enough acres of stripmined land available to absorb the 2020 average daily flow of 654 mgd.

As public acceptance of land treatment grows, more and more of the effluent could be applied to agricultural lands and less and less to the stripmines. Eventually, all the stripmined lands could be restored and the application of effluent to them either eliminated entirely or reduced to the point where leaching would no longer be a problem.

3. Disadvantages of this plan include the following:

a. Land Use

Land needed for reservoir sites within the Tuscarawas basin is likely to be closer to population centers. The potential for alternate beneficial uses, eg., residential or recreational is likely to be greater.

b. Distribution of Effluent

Due to natural soil distribution and development patterns, the suitable agricultural lands in this area are more scattered than in the west. Therefore distribution systems will be more complicated and more expensive if the effluent is moved from the stripmined lands to the agricultural lands.

The S.O.B. land treatment plan outlined above is admittedly based upon incomplete information. One could reasonably take issue with the assumptions relating to all of the following:

(1) The extent to which the leaching of minerals will be a problem.

(2) The precise cost estimates for a) transmitting the effluent to the S.O.B. area, b) distributing the effluent within the S.O.B. area and c) returning the treated water to the Lake Erie drainage area.

(3) The acceptable application rates for stripmined land.

Nevertheless, it does appear that the matter is worth pursuing further. The possibility of significant cost saving cannot be ruled out at this point. But perhaps more important is the possibility that implementation would be far easier for the S.O.B. plan than for any of the other land treatment alternatives being considered. Implementation requires either the purchase of large amounts of land and their management by a public authority, or rather cumbersome legal arrangements between current land owners and the public wastewater disposal authority. Regardless of the method of implementation, serious objections are likely to be raised both by the individual landowners involved and by the general public. The concept of using "good" land for the treatment of wastewater is not meeting with overwhelming support from the populace. The public may very well be mistaken in their views of land treatment, but early efforts to educate them have not been markedly successful.

The use of stripmined land might remove, or at least mitigate a number of the problems associated with implementation. First, stripmined land currently has a negative productivity; it pollutes while producing nothing of value. It would seem that public

acceptance could be achieved if the application of the effluent actually did reduce the pollution emanating from the stripmined land. Seemingly, there are no negative effects present to offset this positive environmental impact. Second, the necessary arrangements with land owners should be considerably easier to make. As it stands the stripmined land is virtually worthless and uninhabited. This should make either direct purchase or the acquisition of the necessary legal rights for effluent application a relatively simple matter. Furthermore, public ownership and renovation of stripmined lands would undoubtedly be more acceptable than public ownership and operation of productive farm lands. The legal arrangements would also be facilitated by the fact that the stripmined land is held in relatively large tracts.